HANDBOOK

OF THE

HOSPITAL CORPS

UNITED STATES NAVY

1939

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The Handbook of the Hospital Corps, United States Navy, 1939, is a revised edition of the former Handbook of the Hospital Corps, United States Navy, 1930, and is compiled from articles prepared by members of the Medical, Dental, Hospital, and Nurse Corps, U. S. Navy, and reviewed and revised by Commander W. J. C. Agnew, Medical Corps, and Chief Pharmacist N. L. Saunders, U. S. Navy. It is published for the instruction and guidance of members of the Medical Department of the United States Navy and for use at the Hospital Corps Schools.

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ROSS T. MCINTIRE.
Surgeon General, U. S. Navy.

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FOREWORD

In this 1939 edition of the Handbook of the Hospital Corps, U. S. Navy, the subject matter has been revised, enlarged, and brought up-to-date, as nearly as possible, with the sciences which are briefly discussed in the various chapters and sections.

The handbook is intended to serve as a general guide and reference book for the hospital corpsmen of the Navy, especially those performing duty independent of medical officers, and as a textbook for their instruction in the Hospital Corps Schools and elsewhere. It contains information and instructions concerning the duties of the Hospital Corps of the Navy, but hospital corpsmen, particularly those in the upper ratings, are urged to make frequent reference to the U. S. Navy Regulations, the Manual of the Medical Department, U. S. Navy, the manuals of other Navy Department bureaus, circular letters, etc., for additional information and instructions.

The principal subjects have been arranged in the order in which they occur in examinations for advancement in rating. As these subjects necessarily are presented in epitomized form, readers of the handbook should realize that the information contained in it must be supplemented by reference to the standard textbooks and professional journals usually available in the medical libraries of hospitals, ships, and stations.

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CHAPTER I

HISTORY OF THE HOSPITAL CORPS OF THE UNITED STATES NAVY

Prior to 1898 the duties attendant upon the care of the sick and injured of the Naval Establishment were performed by certain individuals whose appointment or enlistment was provided for from time to time, under various designations and titles, by order of the Navy Department.

In the earliest days of the Navy, afloat, the care of the sick and injured devolved upon the surgeon and the surgeon's mate, with the assistance of such members of the crew as were detailed to help in emergencies.

An act of Congress, approved March 2, 1799, provided: "A convenient place shall be set apart for the sick and hurt men, to which they are to be removed * * * and some of the crew shall be appointed to attend them, and keep the place clean." The place assigned on board ships for the care of the sick, in accordance with the above act, was usually referred to as the "cockpit" and in later years it was designated as the "sickbay."

The "loblolly boy" was the title designating the man or boy first specifically detailed to assist in the care of the sick and injured. The name probably originated in the British Navy, as it appears in some of the early writings on that service. The first official use of the title in the United States Navy appears in the Naval Regulations published in 1814 where it is stated: "The loblolly boy is to serve the surgeon and surgeon's mate."

The following is quoted from United States Naval Regulations, 1818: "The surgeon shall be allowed a faithful attendant to issue, under his direction, all supplies and provisions and hospital stores, and to attend the preparation of nourishment for the sick.

"The surgeon's mates shall be particularly careful in directing the loblolly boy to keep the cockpit clean, and every article therein belonging to the Medical Department.

"The surgeon shall prescribe for casual cases on the gun deck every morning at 9 o'clock, due notice having been previously given by his loblolly boy by the ringing of a bell."

The loblolly boy was succeeded by a male "nurse" in accordance with a general order of the Navy Department of June 16, 1861, which stated: "There shall be allowed to each vessel commissioned for sea service, with a complement of less than two hundred, one nurse, and with two hundred and over two nurses * * * to be appointed by the surgeon and approved by the commander of the ship, and to be borne upon the ship's books for special service upon the sick."

About the year 1873 the title of "bayman" came into use, and this title was recognized officially in the United States Naval Regulations published in 1876, and it remained in effect until the organization of the Hospital Corps of the Navy in 1898.

Baymen were enlisted as landsmen for general service, and rated bayman by the commanding officer on the recommendation of the surgeon, or senior medical officer. The number was regulated by the complement of the vessel.

The record of the advent of surgeon's stewards in the Navy is more or less obscure, but this seems to have been shortly after the Bureau of Medicine and Surgery was established in 1842. The following is an extract from a letter found in the old files of the bureau under date of May 5, 1843.

"A circular is now under consideration to allow a surgeon's steward to all hospitals and vessels, without necessity to sign articles, but to be appointed."

The Medical Journal of the U. S. S. *Rapidan*, 1844, bears a notation that an applicant for surgeon's steward was found disqualified for appointment on account of physical disability.

Originally surgeon's stewards were enlisted as landsmen or seamen, and were appointed by the commanding officer on the recommendation of the surgeon of the vessel. They were classed as petty officers and could be disrated for incompetency or misbehavior.

By general order of the Navy Department, November 11, 1861, their status was changed to "appointed petty officer"; appointments were made for the "duration of the cruise" and they were subject to discharge for misbehavior, "the fact of misbehavior to be established by a summary court."

The title of surgeon's steward was changed to apothecary by circular order of the Navy Department, dated December 8, 1866. This order reads: "The designation of persons serving as surgeon's steward is changed to that of apothecary, and they will be appointed for duty in the Medical Department of the Navy, ashore and afloat, in the same manner as surgeon's stewards have heretofore been appointed. Apothecaries of the first class will rank with boatswains, * * *, Apothecaries of the second class will rank with boatswain's mates in charge, * * *, Apothecaries of the third class will rank with boatswain's mates."

United States Naval Regulations, 1893, article 1683, prescribed that: "Apothecaries for shore stations shall, with the approval of the Secretary of the Navy, be appointed by the Chief of the Bureau of Medicine and Surgery."

United States Naval Regulations, 1896, article 797, prescribed that: "A candidate for examination and first enlistment as apothecary must be a graduate of some recognized college of pharmacy."

The title of "apothecary" was changed to "hospital steward" by act of Congress of June 17, 1898.

The Hospital Corps of the United States Navy came into existence as an organized unit of the Medical Department under the provisions of an act of Congress, approved June 17, 1898.

This act established the grade of pharmacist, and the ratings of hospital steward, hospital apprentice, first class, and hospital apprentice; provided for appointments to the grade of pharmacist, and the enlisted ratings; fixed the pay and allowances; and specified the duties to be performed.

An act of Congress, approved August 22, 1912, provided that pharmacists after 6 years from date of warrant and after satisfactorily passing the prescribed examination should be commissioned chief pharmacists, and when so commissioned, have the rank, pay, and allowances of a chief boatswain.

The present organization of the Hospital Corps is in accordance with an act of Congress, approved August 29, 1916, and it is considered of sufficient importance, as a matter of general information to all hospital corpsmen, to quote the text of this act relating to the Hospital Corps in full.

"Hereafter the authorized strength of the Hospital Corps of the Navy shall equal three and one-half percentum of the authorized enlisted strength of the Navy and Marine Corps, and shall be in addition thereto, and as soon as the necessary transfers or appointments may be effected the Hospital Corps of the United

States Navy shall consist of the following grades and ratings: Chief pharmacists, pharmacists, and enlisted men classified as chief pharmacist's mates; pharmacist's mates, first class; pharmacist's mates, second class; pharmacist's mates, third class; hospital apprentices, first class; and hospital apprentices, second class; such classifications in enlisted ratings to correspond respectively to the enlisted ratings, seaman branch, of chief petty officers; petty officers, first class; petty officers, second class; petty officers, third class; seaman, first class; and seaman, second class: *Provided,* That enlisted men of other ratings in the Navy and in the Marine Corps shall be eligible for transfer to the Hospital Corps, and men of that corps to other ratings in the Navy and the Marine Corps.

"The President may hereafter, from time to time, appoint as many pharmacists as may be deemed necessary, from the rating of chief pharmacist's mate, subject to such moral, physical, and professional examinations and requirements as to length of service as the Secretary of the Navy may prescribe: *Provided,* That the pharmacists now in the Hospital Corps of the United States Navy or hereafter appointed therein in accordance with the provisions of this act shall have the same rank, pay, and allowances as are now or may hereafter be allowed other warrant officers.

"Pharmacists shall, after 6 years from the date of warrant, be commissioned chief pharmacists after passing satisfactorily such examinations as the Secretary of the Navy may prescribe, and shall, when so commissioned, have the same rank, pay, and allowances as now or may hereafter be allowed other commissioned warrant officers: *Provided,* That the pharmacists at present in the service who have served or may hereafter serve 6 or more years in that grade shall be eligible for promotion to the grade of chief pharmacist upon satisfactorily passing the examinations provided for in this act.

"The Secretary of the Navy is hereby empowered to limit and fix the numbers in the various ratings.

"Section three of an act entitled 'An act to organize a Hospital Corps of the Navy of the United States; to define its duties and regulate its pay,' approved June seventeenth, eighteen hundred and ninety-eight, be, and the same is hereby repealed, and the pay, allowances, and emoluments of the enlisted men of the Hospital Corps shall be the same as are now, or may hereafter be, allowed for respective corresponding ratings, except the rating of turret captain of the first class in the seaman branch of the Navy: *Provided,* That the pay of the rating of the chief pharmacist's mate shall be the same as that now allowed for the existing rating of hospital steward.

"Hospital and ambulance service with such commands and at such places as may be prescribed by the Secretary of the Navy, shall be performed by members of said corps, and the corps shall be a constituent part of the Medical Department of the Navy; and the enlisted men thereof shall be a part of the enlisted force provided by law for the Navy.

"Officers and enlisted men of the Medical Department of the Navy, serving with a body of marines detached for service with the Army in accordance with the provisions of section sixteen hundred and twenty-one of the Revised Statutes, shall, while so serving, be subject to the rules and articles of war prescribed for the government of the Army in the same manner as the officers and men of the Marine Corps while so serving."

CHAPTER II

ANATOMY AND PHYSIOLOGY

General introduction.

If the hospital corpsman is to intelligently perform his duties in caring for the sick and injured he must not only have a good, general knowledge of the structure of the human body but he must also know considerable about the complicated mechanism that constitutes human life. In this chapter human anatomy and some simple physiology will be presented in as brief a way as is consistent with providing the elementary information which the hospital corpsman needs in his work and a ready source to which he can turn for study and review. Between the structure and function of the various parts of the body there exists an intimate relationship that cannot possibly be covered in an abridged chapter such as this must necessarily be. For the hospital corpsman in whom there is aroused a real interest in the anatomy and physiology of the human body fuller text-books must be consulted and studied. In this chapter anatomy will be discussed more completely than physiology, the discussion of which will principally concern the essentials of function.

All objects existing in Nature are commonly classified into three grand divisions or groups called the animal, vegetable, and mineral kingdoms. Objects in the mineral kingdom are without life, are known as *inorganic*, and are made up of *inorganic matter*. Objects belonging to the animal and the vegetable kingdoms are known as *organic*, are made up of *organic matter*, and possess life, that quality or character which distinguishes an animal or a plant from inorganic or from dead organic bodies. By organic matter is implied the organization or arrangement of materials in the way that can be accomplished only through the processes of life.

Any living thing, whether animal or vegetable, is spoken of as an *organism*. Animal organisms are distinguished from vegetable organisms by fundamental differences in their processes of life. Stated in a very general way, vegetable life builds up substances in the organism from water vapors and carbon dioxide in the air and from solutions of mineral salts in the soil, while animal life absorbs complex substances such as proteins and carbohydrates and brings about their oxidation in the organism with absorbed oxygen. Animal organisms possess the attributes of sensation and voluntary motion, while vegetable organisms, though exhibiting irritability in response to stimuli, are generally without voluntary motion or true sense perception; animal organisms receive and digest solid food in an internal cavity previous to its absorption and use, while vegetable organisms make their own food from simple raw materials and utilize it directly within the tissues of the organism; at least part of the food required by animal organisms must be protein matter derived from the bodies of other animal organisms or from vegetable organisms; the life processes of an animal organism must be such that oxygen is absorbed and carbon dioxide produced during its life.

The building up of substances in the vegetable organism, or plant, from simple raw materials, is a process dependent on the presence of a green-colored pigment called *chlorophyll* in the plant and on the radiant energy of the sun.

In a chemical sense this process, which is known as *photosynthesis*, is one of *reduction*. At the same time *synthesis*, or reconstruction, takes place, and two of the products of the process are proteins and carbohydrates, both of which are required in the life processes of animal organisms.

The oxidation of substances in the animal organisms, or animal, is, chemically, a *decomposition* process, and two of the products are carbon dioxide and water vapor, both of which are required in the life processes of plants. For this process the presence of absorbed oxygen in the animal is necessary.

The animal uses portions of plants, either dead or alive, to obtain proteins and carbohydrates. These it decomposes and returns to the air and soil as animal waste products in the form of carbon dioxide and water. The plant, through its green coloring matter and the light rays of the sun, recovers the carbon dioxide and water, synthesizes them into proteins and carbohydrates, and at the same time returns oxygen to the air. It is therefore quite evident that the life processes of plants and animals are closely related and necessary to each other.

The life processes of animals and plants are largely chemical in nature and are proceeding continually in living cells. They are concerned in the building up and destruction of protoplasm, the essential substance of living cells, incidental to the manifestation of vital phenomena, and when considered collectively are spoken of as *metabolism*.

The living organisms called animals are classified according to their natural relationships, the organization of their bodies, and their characteristics or attributes. In this classification the division of *vertebrates* (those with a backbone) stands first, and the highest class of vertebrate animals is that known as the *mammalia* (those which nourish their young with milk).

One of the members of the class of mammalia is man, considered to be the highest type of animal existing or known to have existed. Of all animals man is the only one possessing the power of articulate speech and it is largely because of this power that man has the capacity of abstract reasoning, the extraordinary mental development that is the most characteristic difference between man and other animals. Man is commonly spoken of as a human, or a human being, and it is the structure and life processes of the human being that will be dealt with in this chapter.

The human body is composed of a combination of several systems of organs contained within a supporting framework and the whole surrounded with an external covering. The systems of organs fulfill special functions and are divided into their component tissues which are collections of the fundamental life unit, the animal cell. The study of the human body is divided into a number of closely related sciences which are named according to the structures or parts of the body with which they deal.

Broadly speaking, *anatomy* is the science which treats of the structure of animals or plants. General anatomy deals with the tissues and their properties regardless of the organs into which they are formed. Because the characters of these tissues are to be made out only with the aid of the microscope, general anatomy is practically synonymous with histology. Gross anatomy deals only with the structures and characters discernible with the naked eye.

Human anatomy is the study of the structure of the body of man and the relation of its parts, one to another. It is divided into *descriptive anatomy*, which deals with the character, form, size, and position of organs and parts, *surgical anatomy*, which treats of the situation and relative position of organs and parts as affecting their liability to injury and their accessibility to surgical operations, and *topographical anatomy*, which treats of the anatomy of par-

ticular regions or parts of the body with reference to medical diagnosis and to surgery. It may be divided also into *osteology, arthrology, myology, neurology, angiology,* and *splanchnology,* or the anatomy of the systems of the body.

Physiology is the study of the functions and activities of the various parts and organs of living bodies, and is sometimes described as "the physics and chemistry of living matter." It is that branch of the science of biology which deals with the processes, activities, and phenomena incidental to and characteristic of life or of living organisms. These processes and phenomena include many that are chemical, physical, and mechanical, as well as others apparently of a peculiar nature, but those which are purely mental are not usually included in the ordinary scope of physiology, being considered under *psychology,* the science of mind.

Embryology is the study of the origin and development of the body and its organs.

Histology is the study of the minute structure of the normal tissues of the body. It is sometimes called microscopical anatomy and is a synonym for general anatomy.

Pathology is the study of the changes in structure and function of the various parts and organs of the living body that occur in disease.

Biology is the general study of all forms of life. In its broadest sense it includes *botany,* the science of vegetable life, *zoölogy,* the science of animal life, *cytology,* the science of cell-formation and cell-life, *anatomy, physiology,* and allied sciences. It involves the study of the origin, development, structure, functions, and distribution of plants and animals, and the more generally occurring phenomena accompanying their life, growth, and reproduction. As man is but a complex animal organism it becomes apparent that in studying human anatomy and physiology one is but studying branches of general biology, and a real understanding of human anatomy and physiology must be prefaced by some knowledge of elementary biological principles. Certain of those principles have been very briefly discussed in the paragraphs pertaining to living organisms and their life processes, and the fundamental unit of life, the *cell,* will next be considered.

The cell is the structural unit of which animals and plants are built up. Usually microscopic in size, it consists of a small mass of *protoplasm* called the cell *body,* or *cytoplasm,* in which is a smaller body of modified protoplasm called the *nucleus,* and is enclosed in a more or less resistant outer covering, the cell *wall.* The cell wall in animal cells, when present, is usually of soft, nitrogenous material, while in plant cells it is composed almost wholly of cellulose. The hard parts of animal tissues are materials secreted by the cells and are not a part of the cells.

Protoplasm is the viscid, jelly-like material which constitutes the essential substance of living cells and upon which all the vital functions of nutrition, secretion, growth, reproduction, irritability, and motility depend. It is regarded as the only form of matter in which, or by which, the phenomena of life are manifested, and is hence often called the physical basis of life.

The simplest forms of both animal and vegetable life are made up of only one cell. Yeast and bacteria are unicellular vegetable organisms; the amœba is a unicellular animal organism. In an organism composed of only one cell that cell must necessarily have the full variety of characteristics that will enable it to carry out all the processes of life of the organism. Such a cell is called a *simple cell,* an *unspecialized* or *undifferentiated* cell. An organism so constituted reproduces by a simple and equal division of its cell into two cells, each of which grows and is capable of again dividing.

Cells vary in the shape, size and structure of the protoplasm, in the shape, size and location, and sometimes in the number, of the nucleus within the cell, and in staining qualities.

In more complex forms of life the single organism is made up of many cells with varying characteristics. Certain groups of cells are *specialized* to perform special functions, one group specialized in performing one function, other groups differentiated to perform other special functions, with consequent variations in structure and composition. In a given organism masses or groups of specialized cells similar in structure and function are called *tissues.* A delimited mass of highly specialized tissue is termed an *organ.*

The human body is made up of animal cells, all of which, with the exception of the red blood cells, consist of the cytoplasm, nucleus, and usually the cell wall. The nucleus is highly specialized in structure and function, is enclosed in a delicate membrane, and inside of it is a network of material called *chromatin.* In the cytoplasm and near the nucleus is a minute structure called the *centrosome* which is concerned with the changes which take place when the cell reproduces (fig. 1).

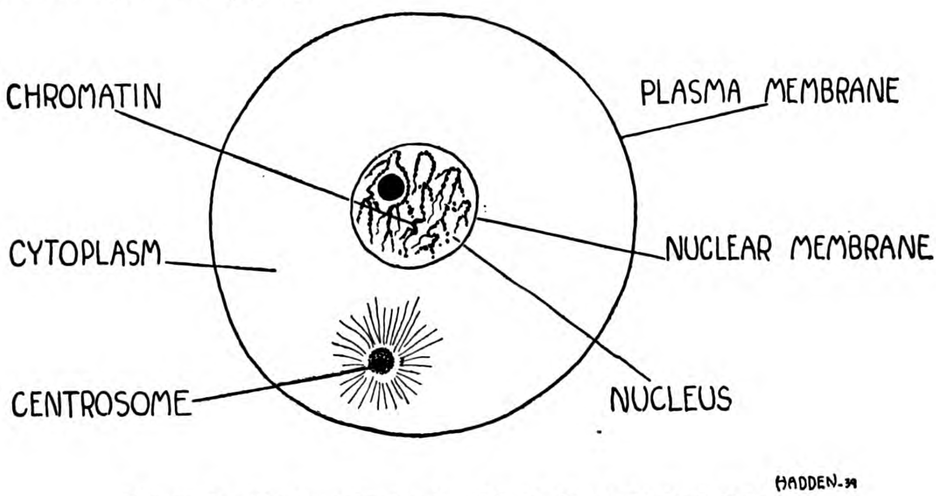


FIGURE 1.—Simple animal cell. (U. S. Naval Medical School.)

The cell wall, or *plasma membrane,* when present as a distinct layer, is a very thin, condensed film surrounding the cytoplasm, from which it differs in some way. Frequently it can be recognized only because certain substances can and others cannot penetrate it.

Animal cells all are able to *grow* and mature, they can be stimulated into activity, which property is known as *irritability* or *excitability,* and they can *reproduce.*

It is known that protoplasm consists chiefly of proteins, salts, and water, and for the growth of cells these substances must be supplied in a form that can be absorbed and used. A fluid called *tissue fluid,* which is derived mainly from the blood and contains the food substances required, bathes the cells and is their source of nutrition. If for any reason they are deprived of tissue fluid cells cease to grow and die. After reaching maturity cells may remain indefinitely in that state or may reproduce.

Cell irritability may be caused by mechanical, chemical, and nervous forms of stimulation, the action of heat and light, etc. Singly, the cause is called a *stimulus,* collectively, they are called *stimuli.* The result of cell stimulation may be noted as a movement or alteration of the shape of the cell, as in

muscular movements, by the liberation of substances secreted by the cell, as in the flow of digestive juices, and in other ways. The stimuli exciting the cell into activity usually are the impulses carried by nerves to the cell, or the action of chemical substances which reach the cell from the blood through the tissue fluid.

The **reproduction** of cells in the human body occurs during the period when the organ or tissue of which the cell is a part is growing and lasts until the maximum growth of the whole body has been reached. After that cells may reproduce to replace those destroyed by injury or disease or that have become worn out. Cell reproduction takes place by the parent cell dividing equally into two daughter cells. Each daughter cell contains half the substances in the parent cell and exhibits all the properties of the parent cell. It is thought that new cells inherit the characteristics of the parent cell through the chromatin in the nucleus.

When a cell reproduces by division the process begins by the chromatin in the nucleus elongating into structures called *chromosomes* and the centrosome near the nucleus developing two star-shaped structures called *asters*, each of which has a central mass that becomes the centrosome in the new cell, and radiating fibers called *aster rays*. The fibers between the two central masses of the asters begin to form a structure shaped like and called a *spindle*, the membrane enclosing the nucleus bursts and the chromosomes become attached to the fibers of the spindle. By the time development of the spindle is completed the chromosomes have been drawn into the equator of the spindle and begun to split into equal halves. The halves then separate and the spindle begins to divide at its equator, the chromosomes group themselves at the spindle poles, the aster rays disappear, and the cell body begins to divide. When division of the cell body is finished two new cells have been formed and the process of reproduction is complete (fig. 2).

Cell reproduction by this form of division in which there are extensive preliminary changes in the nucleus is known as *mitosis* or *mitotic division*. Bacteria reproduce by a simpler form of division called *amitosis* or *amitotic division*, which is also called *fission*.

In man the parent cell is known as the *ovum*, or egg. After leaving the ovary of the mother the ovum unites with the male germ cell or *spermatozöon*, and the union is called the *fertilization* of the ovum. Immediately after this union cell reproduction begins. The fertilized ovum divides into 2 daughter cells, which then divide to make 4, the 4 to make 8, the 8 to make 16, etc. As this division or segmentation goes on, there occurs a gradual differentiation in the cells produced, so that there are cells of several different types, each capable of reproducing others of its kind. Through this process of *fertilization*, *segmentation*, *differentiation*, and *growth* there is finally brought about the complex animal organism known as man.

In a preceding paragraph it was stated that when the life processes of animals and plants are considered collectively they are spoken of as metabolism. In these life processes the cells are involved. During periods of cell activity certain parts of the cellular substance become broken down, or destroyed or decomposed. This is sometimes spoken of as destructive metabolism but is usually called *katabolism*. To replace the loss or repair the breakdown of cellular substance the cell takes up nutrient material in a process called *assimilation* and uses it to build up new protoplasm by the process known as *anabolism*.

Tissues, as stated before, are masses or groups of specialized cells similar in structure and function. Tissues have their own characteristic *intercellular*

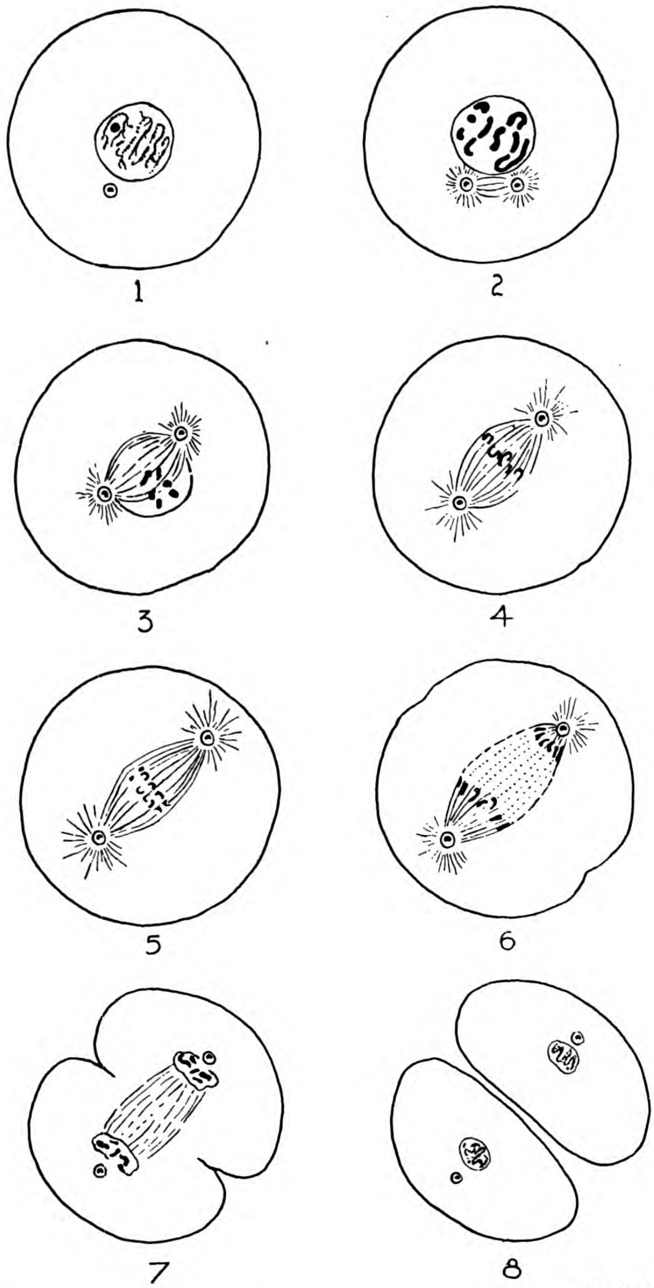


FIGURE 2.—Cell reproduction by mitotic division. 1, Normal cell before commencement of process of reproduction showing network of chromatin in nucleus, and adjacent centrosome; 2, Chromatin elongated into chromosomes and centrosome developing asters and aster rays; 3, Nuclear membrane broken, spindle developing, and chromosomes attached to spindle fibers; 4, Spindle fully developed, with chromosomes in equator; 5, Chromosomes splitting into halves; 6, Chromosomes separated and spindle beginning to divide at equator; 7, Chromosomes grouped at spindle poles, aster rays disappearing, and cell body beginning to divide; 8, Cell body divided and reproduction process complete with two daughter cells formed. (U. S. Naval Medical School.)

substance which joins the cells in it together. Although a tissue may be modified by situation it can always be identified when studied microscopically. The tissues in the adult human body are usually classified into five main groups: 1. *Epithelial tissue;* 2. *Connective tissue;* 3. *Muscular tissue;* 4. *Blood and lymph;* and 5. *Nervous tissue.* Each tissue is characterized by certain peculiarities of structure and function.

The free surface of the skin, the linings of the digestive, respiratory, and urinary tracts, the linings of blood and lymph vessels and serous cavities, and certain important secreting glands as the liver, kidneys, etc., are made up of epithelial tissue, or *epithelium* (fig. 3). Having such different services to perform the cells in epithelial tissue are generally divided according to arrangement and shape into five principal classes as *cuboidal, columnar, flat, squamous,* and *ciliated,* and according to function into *glandular* or *secreting,* and *protective.* The epithelium forming the various linings spoken of is commonly known as *endothelium.* When the cells are arranged in single layers epithelial tissue is called *simple* and when they are arranged in distinct layers one above another it is called *stratified.* Unlike other tissues the cells in epithelial tissue are joined together by thickened lymph instead of intercellular substance.

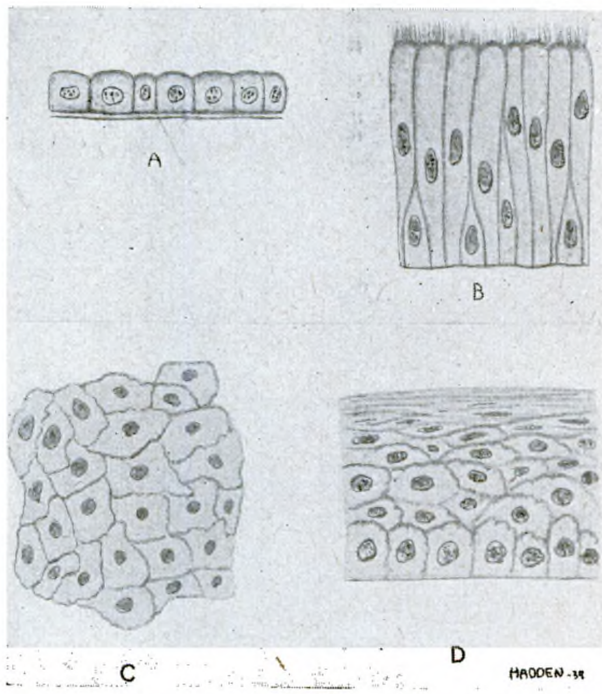


FIGURE 3.—Epithelial tissue. *a,* Cuboidal; *b,* ciliated columnar; *c,* flat; *d,* stratified squamous. (U. S. Naval Medical School.)

The epithelial cells known as ciliated have hair-like appendanges on their free edges whose function is to propel fluid or particles. These ciliated cells also are generally columnar. Other epithelial cells can produce the viscid substance called mucus and the tissues where these cells are located are known as mucous membranes.

Connective tissue is the supporting tissue of the body and has a general distribution (fig. 4). In this tissue the cells are scanty and the intercellular substance is considerable. The principal forms of connective tissue are: 1. *Adipose,* or fat, in which fat-cells are lodged in meshes of areolar tissue and fat replaces most of the cytoplasm; 2. *Areolar,* found beneath the skin and between muscle fibers and also called loose fibrous, in which the cells are enmeshed in a loose network of delicate, elastic fibers interlacing in every direction; 3. *Cartilaginous,* often called gristle, in which the cells lie in cavities of an intercellular substance called the matrix which may be finely granular and translucent, be mixed with white fibrous tissue, or contain a network of yellow elastic fibers; 4. *Elastic,* found in the trachea and bronchi,

the inner coats of blood vessels, and elsewhere in the body, in which the intercellular substance consists of yellow, elastic fibers branching and uniting with one another; 5. *Fibrous*, found in tendons and ligaments and also called dense fibrous, in which the intercellular substance consists of bundles of closely

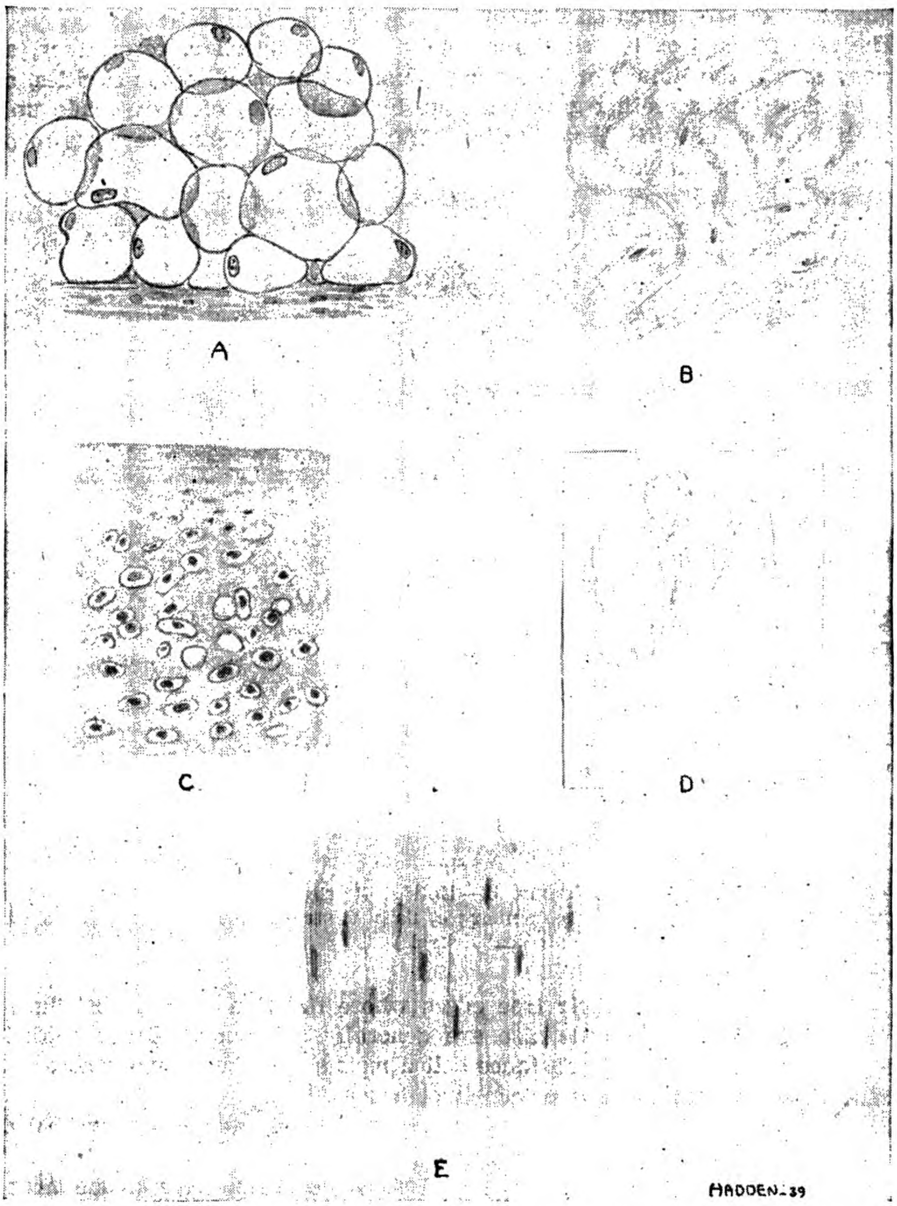


FIGURE 4.—Connective tissue. *a*, Adipose; *b*, areolar; *c*, cartilaginous; *d*, elastic; *e*, fibrous. (U. S. Naval Medical School.)

packed parallel white fibers bound firmly together and with some areolar tissue between the bundles; 6. *Lymphoid*, found in the tonsils, spleen, and lymphatic glands and also called reticular, in which the intercellular substance is largely fluid and consists of a loose network of white fibers containing lymphoid cells; and 7. *Osseous*, in which the intercellular substance is in

layers and may be regarded as white fibrous tissue in which calcium and other mineral salts have been deposited and made it very hard.

Muscular tissue is the tissue of which muscles are formed (fig. 5). It is composed of cells which have been modified and elongated to form thread-like *muscle fibers* held together by delicate connective tissue. Muscle fibers have a reddish color, are lightly covered by elastic, connective-tissue sheaths, are bound together in bundles or fasciculi by delicate connective-tissue envelopes, and those bundles grouped together into larger bundles or sheets to form various *muscles*. Muscular tissue has the following properties: *Irritability*, or response to stimulations usually received from nerves; *contractility*, the power to become shorter and thicker; *tonicity*, a mild, sustained contraction giving the skeletal muscles firmness and maintaining a slight steady pull on their attachments; and *extensibility*, ability to be stretched. Muscular tissue is of three distinct types and the characteristics of each are imparted to the muscles they form. The muscles of the skeleton are known as *striated*, *striped*, or *voluntary*, and

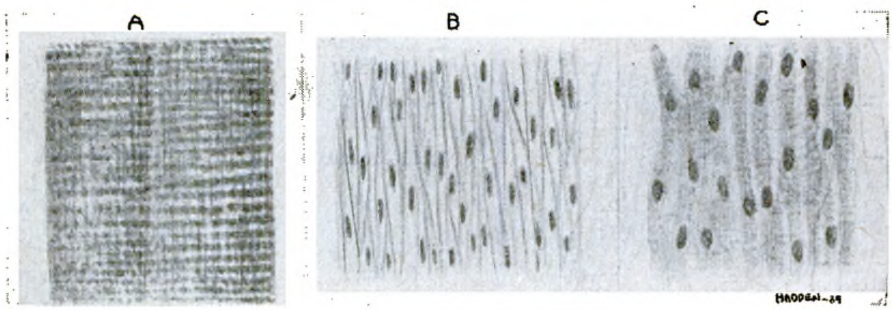


FIGURE 5.—Muscular tissue. *a*, Striated; *b*, nonstriated; *c*, cardiac. (U. S. Naval Medical School.)

the individual cells of this type are elongated, multinuclear, contain transverse striations peculiar to them, and can be controlled by the will; the muscles of hollow internal organs, blood vessels, etc., are known as *nonstriated*, *unstriped*, or *involuntary*, and the individual cells are plain, flattened, without striations, and cannot be controlled by the will; the muscle of the heart is known as *cardiac*, *striated* or *striped* but *involuntary*, and has short, mononucleated cells which branch and unite with adjacent cells, and have striations which are different from those in the skeletal muscles.

Blood and lymph may be considered as tissues consisting of free cells in a fluid intercellular substance which does not join the cells together.

Nervous tissue, composed of nerve cells, nerve fibers, and an intercellular supporting tissue, is the most highly specialized tissue in the body and will be discussed more fully in the section dealing with the nervous system.

Having discussed the masses or groups of cells called tissues the delimited, or bounded, masses of tissues termed organs will next be briefly considered.

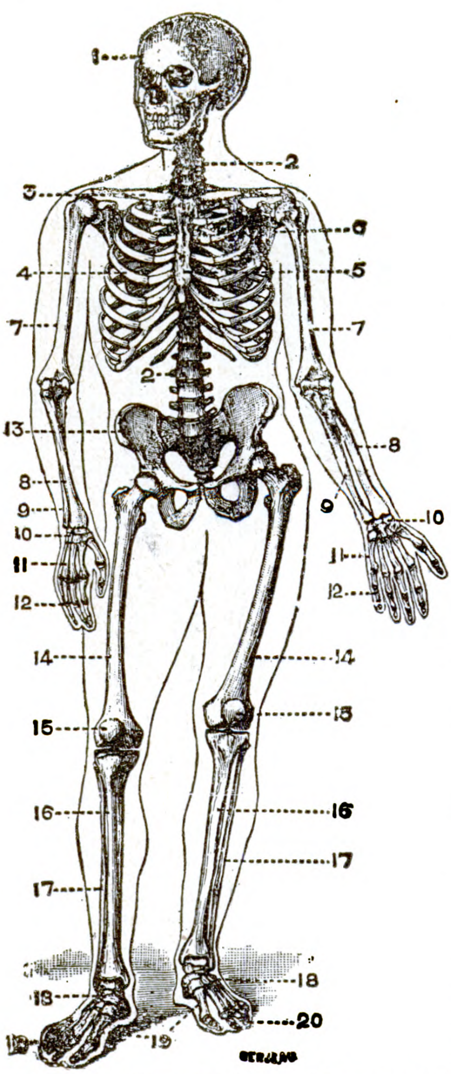
An organ is that part or structure in an animal organism which is adapted for the performance of some specific function, or functions, as the heart, the kidneys, etc. In most multicellular organisms, as in man, the essential and active part of an organ is made up of the particular form of specialized tissue on which the function of the organ depends, while other tissues serve for the support, nutrition, control, etc., of the organ.

Groups of organs which act together and collectively have a common function in contributing toward one of the more important and complex vital functions are known as **systems**, as the digestive system, the nervous system, etc.

In order to understand anatomical descriptions the meaning of the following words should be known: *Anterior*, in front; *posterior*, to the back; *superior*, higher; *inferior*, lower; *internal*, within, inside; *external*, outside; *lateral*, at the side; *medial, median*, in the middle; *ventral*, the abdominal side; *dorsal*, on the back; *proximal*, nearest to a point; *distal*, farthest from a point.

THE BONES AND JOINTS

Osteology is the study of the structure of bones. It also includes the study of the cartilages and ligaments which bind bones together.



1. Cranium.
2. Vertebral column.
3. Clavicle.
6. Scapula.
4. Ribs.
5. Sternum.
7. Humerus.
8. Radius.
9. Ulna.
10. Carpus.
11. Metacarpus.
12. Phalanges.
14. Femur.
15. Patella.
16. Tibia.
17. Fibula.
18. Tarsus.
13. Pelvis.
19. Metatarsus.
20. Phalanges.

FIGURE 6.—The skeleton. (Manual of Instruction, Royal Naval Sick Berth Staff.)

Arthrology or *syndesmology* is the study of the joints or articulations. It takes into consideration the parts forming the joints and the mechanism of each joint.

The **skeleton** is the bony framework of the body (fig. 6). Its function is to support and give shape to the body, to protect certain vital organs, to afford attachments for tendons, muscles, and ligaments, and to act as joined levers by which movements may be accomplished.

Bone, or osseous tissue, has been stated to be one of the connective tissues in which there are deposits of calcium and other mineral salts. These salts normally constitute about 67 per cent of the weight of bone but their amount increases as the body ages with the result that bones become harder and more brittle. By dissolving out the mineral salts or inorganic matter in bone by means of dilute mineral acid an organic substance called *ossein* remains, and this substance, which is perfectly flexible, can be bent and twisted without difficulty.

Bones consist of a hard, outer shell called the *compact tissue*, and an inner, spongy, and porous part called *cancellous tissue*. In long bones a cavity called the *medullary canal* extends the whole length of the shaft. This cavity and

the spaces in the cancellous tissue are filled with a substance called *marrow* which is of two types, yellow and red. Yellow marrow is composed chiefly of fat; red marrow contains little fat but is abundantly supplied with blood and in it are also found reddish-colored, nucleated cells called *erythroblasts* from which red blood cells are formed. The ends and facets of bones are covered with a special variety of cartilage which is called *articular cartilage* and forms the articulating surfaces and enters into the formation of joints. Those parts of bones not covered by articular cartilage are covered with a thin, vascular membrane of fibrous tissue called *periosteum* which, when it reaches the articular cartilage, continues as the *perichondrium*, a fibrous connective tissue covering the surface of the cartilage. Periosteum has the power of generating new bone and does so in the normal growth of bone or when the original bone has been destroyed. Bones are nourished from capillaries in the periosteum which dip down into small pits on the bone surface and from small arteries, one or more to each bone, which enter through small openings called *nutrient foraminæ* and branch out into the marrow and bone tissue, passing through the compact tissue in small passages called canals, those located in the center of concentric rings of compact tissue being known as *Haversian canals* (fig. 7).

FIGURE 7.—Transverse section of compact tissue of bone, showing concentric rings and Haversian canals. Magnified about 150 diameters. (Sharpey.)

Bones are classified by shape as: *Long*, which have two *extremities* and a *shaft* of compact tissue, thickest in the middle where the bone is the most slender and the strain the greatest, and containing the central medullary canal, as the femur, the humerus, etc.; *short*, which are small, irregularly shaped, and made of cancellous tissue throughout except for a thin layer of compact tissue covering the surface, as the bones of the wrist and the ankles; *flat*, which have broad or elongated flat plates of compact tissue enclosing a variable amount of cancellous tissue and afford extensive protection and broad surfaces for the attachment of muscles, as some of the bones of the skull, the sternum, the shoulder blades, and the pelvic bones; and *irregular*, which cannot be placed in any of the other classes because of their peculiar shape and consist largely of cancellous tissue with a thin layer of compact tissue covering the surface, as the vertebræ, the mandible, the hyoid.

Two hundred and six distinct bones make up the skeleton of the adult. In the child there are more, some of which fuse together during growth. In the table following no sesamoid bones (small bones developed in tendons at points of much pressure) except the patellæ are included.

THE BONES OF THE SKELETON

Bones of the skull	22
Bones of the ears (auditory ossicles)	6
Hyoid bone	1
Bones of the vertebral column	26
The sternum	1
The ribs	24
Bones of the upper extremities	64
Bones of the lower extremities (including the patellæ)	62
Total	206

The meaning of the following words used in describing bones should be known: *Process*, a prominence; *tuberosity*, a large process; *tubercle*, a small process; *spine*, a sharp, slender process; *condyle*, a rounded, knuckle-like process; *crest*, a narrow ridge; *head*, a portion of bone supported on a constricted part or *neck*; *fossa*, a depression or pit, a cavity; *notch*, a deep indentation; *groove*, a furrow or channel; *sinus*, a cavity within a bone; *antrum*, a hollow space in a bone; *foramen*, a perforation or opening; *fissure*, a groove.

The bones.

The skull is the bony framework of the head, is elliptical in shape, and is commonly divided into two parts, the *cranium* and the *face* (fig. 8). The cranium is made up of various flat bones which are united in irregular lines called *sutures*, and form the *cranial cavity* which is more or less oval in shape and in life holds the brain. The upper wall of this cavity is called the *vault of the skull;* the floor is called the *base of the skull* and has three distinct *fossæ* or hollows, the *anterior cranial fossa*, the *posterior cranial fossa*, and the *middle cranial fossa*. In the base of the skull are many small *foraminæ* for the passage of nerves and blood vessels to and from the brain. Just posterior to its middle the base has a large round opening, the *foramen magnum*, through which the spinal cord, its coverings, certain cranial nerves, and the vertebral arteries emerge.

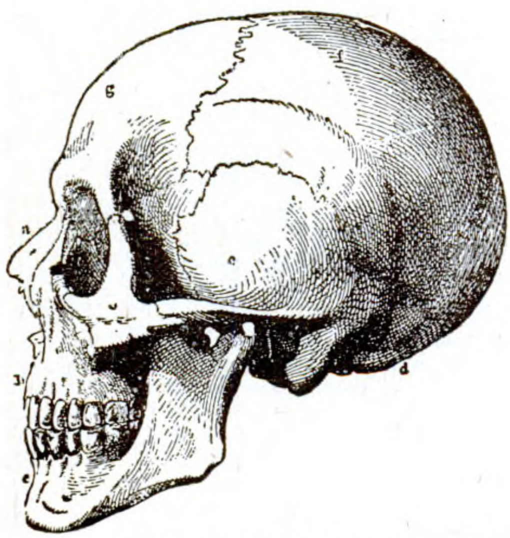


FIGURE 8.—Skull: *a*, Nasal bones; *b*, superior maxilla; *c*, mandible; *d*, occipital bone; *e*, temporal bone; *f*, parietal bone; *g*, frontal bone. (Mason.)

In front and below the cranium are the bones of the face which form two *orbital cavities*, one on each side of the root of the nose, for the eyes, the *nasal cavity* for the passages of the nose, and the *oral cavity* for the mouth.

When the skull is viewed from the side there is seen, just behind the orbital cavity of the eye, a broad depression, the *temporal fossa*, the whole area of which in life affords attachment for the temporal muscle, which closes the jaw. The temporal fossa is limited below by a bony arch, the *zygomatic arch*, or *zygoma*. Just below and posterior to the zygomatic arch is an opening leading into the bone, the *external auditory canal*, below and behind which is a bony prominence called the *mastoid process*. This contains the mastoid air cells, the seat of the inflammation in mastoid disease.

Viewing the skull from below, the foramen magnum is seen just posterior to the middle with an articular surface on either side for articulation with the *atlas*, the first cervical vertebra. Anteriorly on either side are the zygomatic arches, and directly in front, bordered on three sides by the teeth of the upper jaw, is the roof of the oral cavity, the *hard palate*. Just above the hard palate and opening backward are the *posterior nasal apertures*.

The Bones of the Cranium

Occipital	1
Frontal	1
Parietal	2
Temporal	2
Sphenoid	1
Ethmoid	1
Bones of the ear	3×2=6
Total	14

The **occipital bone** forms the posterior part of the vault and the posterior fossa of the base. It contains the foramen magnum.

The **frontal bone** is the bone of the forehead and forms the whole anterior part of the vault. At its lower anterior border it extends abruptly backward on either side to form the roof of the orbital cavity and at the same time the very front part of the floor of the cranial cavity. Just internal to the upper orbital margin on either side it contains large air cells, the *frontal sinuses,* which have openings leading into the nasal cavity.

The **parietal bones** articulate with each other in the mid-line, with the occipital behind and the frontal in front, thus completing the upper part of the vault.

The **temporal bones** are located one on each side of the base. Each has a *squamous* (flat, scale-like) portion extending upward to form a part of the side of the vault and at the same time a part of the floor of the temporal fossa. A process extends forward to form the zygomatic arch, and posteriorly, extending downward, is the heavy mastoid process. Extending inward and forming a large part of the floor of the middle fossa of the base is the *petrous* (stony hard) portion of the bone. This portion contains the organ of hearing and the external auditory canal leading into the ear.

Each middle ear contains three small bones named from their shape, *malleus* (hammer), *incus* (anvil), and *stapes* (stirrup).

The **sphenoid** lies in the base of the skull, between the frontal bone in front, the occipital bone behind, and the temporal bone at either side and behind.

The **ethmoid** lies anterior to the sphenoid. One part of the bone forms a small portion of the floor of the anterior fossa, lying in the mid-line between the orbital parts of the frontal bone. From this part three processes extend downward—a perpendicular plate in the mid-line to form the upper part of the nasal septum, and a process on each side to form the upper lateral wall of the nasal cavity.

The Bones of the Face

Maxillæ	2
Palate bones	2
Vomer	1
Inferior turbinated bones	2
Nasal bones	2
Lacrimal bones	2
Malar or zygomatic bones	2
Mandible	1
Hyoid	1
Total	15

The two **maxillæ** unite to form the upper jaw. In the body of each is a large air cell, the *maxillary sinus* or antrum of Highmore. The lower border of the bone is the *alveolar process* and in this the upper teeth are embedded. Running horizontally inward from just above the alveolar process is a thin plate of bone that unites with its fellow of the opposite side to form all but the very posterior part of the hard palate. Above the hard palate the medial aspect of the bone forms the lateral wall of the nasal cavity.

Each **palate bone** is L-shaped, the horizontal part forming the posterior portion of the hard palate and the vertical part forming the lower posterior portion of the lateral wall of the nasal cavity.

The **vomer** is a thin flat bone that forms the lower posterior part of the nasal septum.

The **inferior turbinated** bones are two small shell-like bones, lying along each lower lateral wall of the nasal cavity, forming a sort of curved shelf.

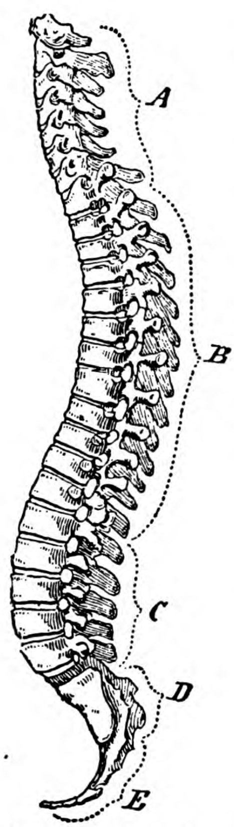


FIGURE 9.—Spinal column: *a*, Cervical; *b*, dorsal; *c*, lumbar; *d*, sacrum; *e*, coccyx. (Mason.)

The **nasal bones** are two small flat pieces of bone, one on each side of the root of the nose, that join in the midline to form the bridge of the nose.

The **lacrimal bones** are two small bones that form a part of the wall of the orbital cavity at its inner and lower angle, one on each side.

The **malar bones** are the cheek bones and underlie the most prominent part of the cheek.

The **mandible** is the horseshoe shaped bone of the lower jaw. The horizontal part of the bone is called the *body*, and the upper part of the body, which supports the teeth, is called the *alveolar process*. The vertical part of the bone on each side is called the *ramus*. The juncture of the ramus and the body is called the *angle of the jaw*. Each ramus is topped by two processes—the *condyloid process* behind, for articulation with the temporal bone, and the *coronoid process* in front, for the insertion of the temporal muscle.

The **hyoid bone** is a small U-shaped bone lying anteriorly in the neck and serving for the attachment of various muscles of the throat and tongue.

THE BONES OF THE NECK AND TRUNK

Vertebræ (true)	24
Sacrum	1
Coccyx	1
Sternum	1
Ribs	24
Total	51

The **spinal column** consists of 24 movable or true vertebræ, the sacrum and the coccyx (fig. 9). Each of the latter two bones are made up of vertebral segments (false or fixed vertebræ) that are fused in adult life.

The **true vertebræ** are irregular bones placed one on top of another with cartilage between, and named according to their location. There are 7 *cervical*, 12 *thoracic* or *dorsal* and 5 *lumbar* vertebræ.

The form of the individual vertebræ, at different levels, varies somewhat, but a typical vertebra may be described as consisting of a *body*, cylindrical in form; a *vertebral arch*, enclosing the *vertebral foramen;* and three processes that act as levers for the attachment of muscles. These three processes spring from the vertebral arch—one on each side, the *transverse process*, and one posteriorly, the *spinous process* (fig. 10). The spinous process may be felt underneath the skin in the mid-line of the back. There are four articular processes that also spring from the arch.

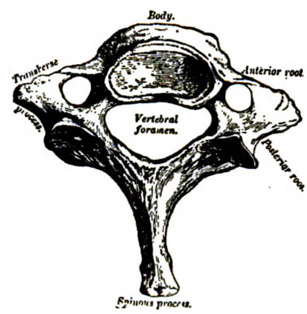


FIGURE 10.—Seventh cervical vertebra. (Gray.)

The **sacrum** is roughly triangular in shape and is formed by the fusion of five false vertebræ. It articulates on each side with a hip bone to form, with the coccyx, the posterior wall of the pelvis.

The **coccyx** is the lower extremity of the spinal column and consists of four, sometimes five, vertebral segments fused together. It corresponds to the tail of lower animals.

The **thorax** is a conical elongated bony cage formed by the sternum and costal cartilages in front, the 12 ribs on each side, and the bodies of the 12 thoracic vertebræ behind. It contains and protects the principal organs of circulation and respiration (fig. 11).

The **sternum** occupies the middle of the upper part of the chest wall in front. It is divided into an upper part, the *manubrium*, a small lower part, the *xiphoid process*, and between these a *body*. It articulates above with the clavicles and on each side with the cartilages of the first seven ribs.

The **ribs,** of which there are 12 pairs, form a series of curved bony bands that support the chest wall. Behind, they articulate with the thoracic vertebræ. In front, each rib is provided with a costal cartilage. The first seven ribs articulate with the sternum by means of their cartilages and are called *true ribs.* The lower 5 ribs are not supported and are called *false ribs.* The eighth, ninth, and tenth are united by their cartilages to the cartilages of the seventh, while the last 2 are free at their anterior ends and are called *floating ribs.*

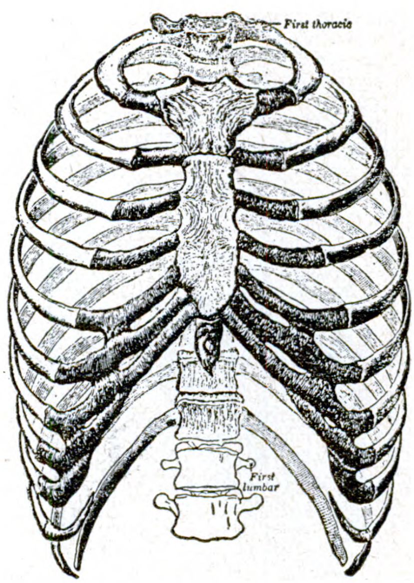


FIGURE 11.—The thorax. Ventral view. (Gray.)

THE BONES OF AN UPPER EXTREMITY

Clavicle	1
Scapula	1
Humerus	1
Ulna	1
Radius	1
Carpal bones	8
Metacarpal bones	5
Phalanges	14
Total	32×2=64

The **clavicle** (collar bone) consists of a rounded curved shaft with enlarged ends. Medially it articulates with the sternum and laterally with the acromion process of the scapula (fig. 12).

The **scapula** (shoulder blade) is a flat bone of roughly triangular shape. From its posterior surface there springs a shelf-like process, the *spine*. At the outer end of the spine is the *acromion process*, with an articular facet for the clavicle. At the extreme lateral root of the spine is a constriction of the upper lateral angle of the bone. This constriction is the *neck*, and beyond it is the *head*. The head supports the *glenoid cavity*, for articulation with the head of the humerus, and above this is a beak-like projection, the *coracoid process* (fig. 13).

FIGURE 12.—The clavicle. (Mason.)

The **humerus** is the bone of the arm (fig. 14). It articulates proximally with the glenoid cavity of the scapula and distally with the ulna and the radius. It is made up of a *head*, an *anatomical neck*, a *surgical neck*, a *shaft*, and a *distal extremity*. The distal extremity has on each side a prominence, the *medial* and the *lateral epicondyles*. Below these are two articular facets, one for the ulna and one for the radius.

The **ulna** is placed on the medial side (little-finger side) of the forearm (fig. 15). It is a long bone, much larger at its proximal end, where it has a promiment process, the *olecranon*. This forms the point of the elbow. The ulna articulates with the radius at both ends and with the humerus proximally. At its very distal extremity is a *styloid process*, which can be felt beneath the skin on the inside of the wrist.

FIGURE 13.—Posterior aspect of right scapula. (Potter.)

FIGURE 14.—Humerus. (Potter.)

FIGURE 15.—Radius and ulna. (Mason.)

The **radius** is placed on the lateral side (thumb side) of the forearm (fig. 15). It is a long bone, much larger below than above. It articulates above with the humerus and the ulna and below with the carpal bones and the ulna. On its lower end it has a *styloid process* that can be felt beneath the skin on the outside of the wrist.

The **carpal bones** are small six-sided bones arranged in the wrist or *carpus* in two rows. The distal row, or row nearest the finger tips, contains, beginning from the radial side of the wrist, the *greater multangular*, *lesser multangular*, *capitate*, and *hamate* bones. The proximal row, or row nearest the elbow, contains, beginning from the radial side of the wrist, the *navicular*, *lunate*, *triangular*, and *pisiform* bones.

The **metacarpal bones** are located in the palm. The proximal end of each is called the *base* and it articulates with the carpus. The shaft extends through the palm, and the *head*, or distal end, articulates with the *proximal phalanx* of the corresponding digit. The metacarpals are numbered from 1 to 5, beginning at the thumb side.

There are three *phalanges* in each finger and two in the thumb. The phalanx at the end of the digit is called the *distal phalanx*, the one next to the hand the *proximal phalanx*, and the one between, the *middle phalanx*.

THE BONES OF A LOWER EXTREMITY

Innominate bone	1
Femur	1
Patella	1
Tibia	1
Fibula	1
Metatarsal bones	5
Tarsal bones	7
Phalanges	14
Total	31×2=62

The **innominate bone** (hip bone) is made up of three parts, the *ilium*, the *ischium*, and the *pubis*. In adult life these three parts are fused together. The pubis lies below and in front, joining with the pubic part of the opposite bone to form the *symphysis pubis*. The ischium lies below and to the back, while above and posteriorly is the large flat portion of the bone, the ilium. At its central part the bone is heavy and on its outer aspect there is a deep cavity, the *acetabulum*, for articulation with the head of the femur. Just below the acetabulum is a large opening, the *obturator foramen*. Posteriorly the iliac portion of each bone articulates with the sacrum, and, with coccyx, forms the *pelvis* (fig. 16).

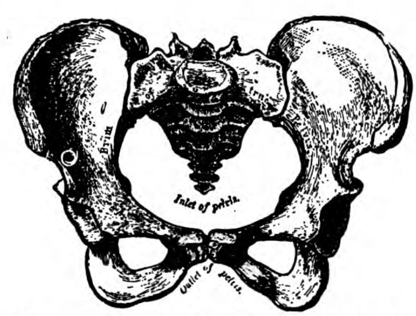


FIGURE 16.—Pelvis (adult.) (Gray.)

The **femur** is the bone of the thigh and the longest bone of the body (fig. 17). It is composed of a *proximal* end, a *distal* end, and a *shaft*. The proximal end is made up of a *head*, a *neck*, and two processes called the *greater* and *lesser trochanters*. The head fits into the acetabulum to form the hip joint. The distal end is made up of two *condyles* which articulate with the tibia.

FIGURE 17.—Femur. (Mason.)

The **patella**, a sesamoid bone, overlies the front of the knee joint and is in the tendon of the quadriceps muscle.

The **tibia,** or shin bone, is the larger of the two bones of the leg and it lies to the inner side (fig. 18). The proximal end of the bone has the *medial* and *lateral condyles* for articulation with the femur. The lateral side of the outer condyle articulates with the fibula. The distal extremity is smaller than the proximal. Medially it presents a prominence, the *internal malleolus,* distally an articular surface for the talus, and laterally a smaller articular surface for the fibula.

Figure 18.—Tibia and fibula. (Mason.)

The **fibula** is the slender bone lying on the outer side of the leg (fig. 18). It has two enlarged ends. The upper end articulates with the tibia alone. The lower end articulates with the tibia and also with the talus. The outer prominent portion of the lower end of the bone is called the *lateral malleolus.* It can be felt beneath the skin.

There are seven **tarsal bones** in each ankle, the *talus,* which articulates with the tibia and fibula to form the ankle joint, the *calcaneus,* the heel bone, the *navicular,* a boat-shaped bone; the *first, second,* and *third cuneiform,* and the *cuboid* bones.

The **metatarsal bones** are similar to the metacarpal but are slightly longer and heavier.

The **phalanges** of the toes are similar to those of the fingers but are shorter.

The joints.

Joints, or articulations, are the connections by which the various bones of the skeleton come together. There are two types of joints, the *immovable,* whose object is to preserve the rigidity of the bones joined together, and the *movable,* whose object is to permit movement of the bones joined together, and which may be either freely or partly movable. The best example of the immovable joint is in the skull where the bones are "dovetailed" together; the hip and shoulder joints are examples of freely movable joints; and the articulations of the pubic bones in the pelvis and the lower ends of the tibia and fibula are examples of partly movable joints.

The substances which enter into the formation of joints vary with the character of the joint. In every joint there are two or more skeletal elements (bone or cartilage) and a uniting substance or medium, the amount and kind of which depends on the type of the joint. The uniting substance in immovable joints is a very thin layer of fibrous tissue which corresponds to and is continuous with the periosteum, or is of cartilage, while in movable joints it is fibrous and fibrocartilaginous material, and cartilage.

Movable joints have a cavity separating the bones entering into them. Cartilage covers the articulating surfaces of the bones in movable joints and in some joints there are also discs of cartilage in the joint cavities. The bones entering into the joint are held together by strong bands of fibrous tissue called *ligaments,* which pass from one bone to the other on every side of the joint and form a *capsule* which is the external boundary of the joint cavity. This fibrous capsule is lined with *synovial membrane* which secretes a substance called *synovial fluid* that is retained in the cavity and serves to lubricate the joint (fig. 19).

According to their type of movement, movable joints are known as *gliding,* as those between the articular processes of the vertebræ, *hinge,* as the elbow, knee, finger, and toe joints, *ball and socket,* in which the round head of one bone fits into a cup-like cavity in another as in the hip and shoulder joints, *rotary,* in which one bone rotates on one which is stationary, as the first and

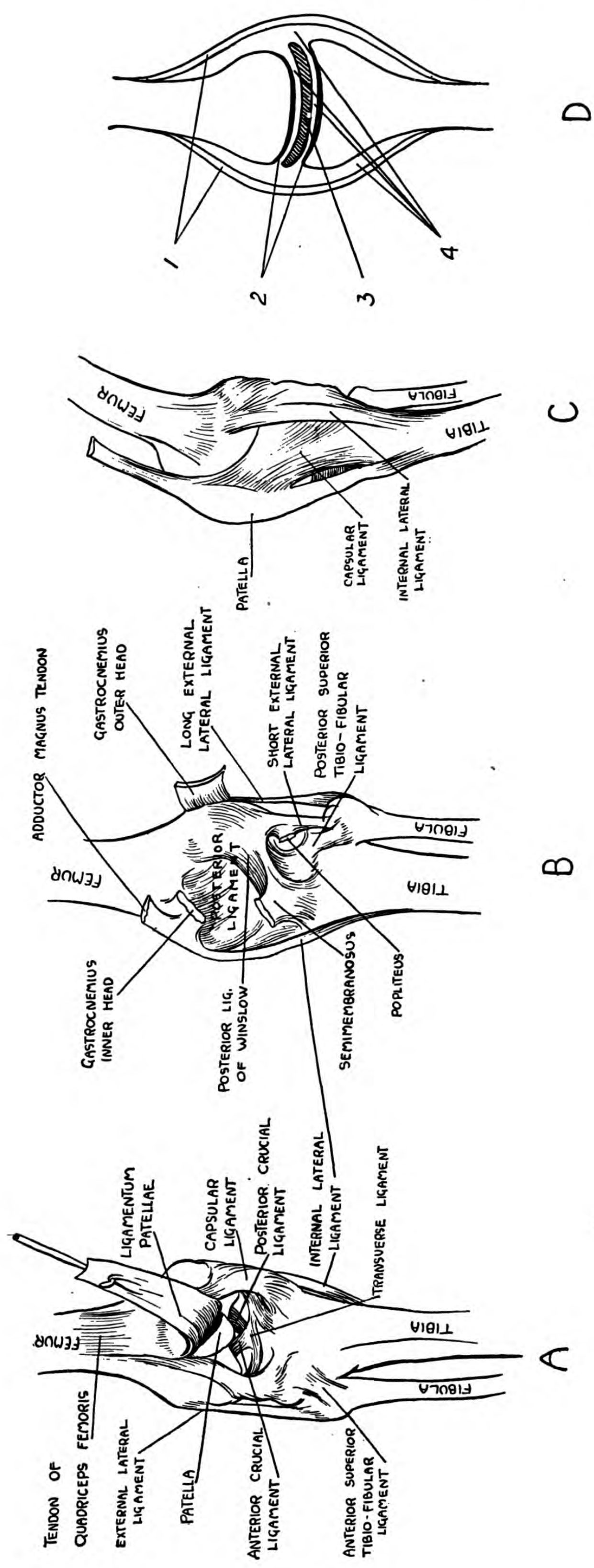


FIGURE 19.—Anterior, *a*, posterior, *b*, and lateral, *c*, views of left knee joint; *d*, schema of a movable joint showing: 1, capsular ligaments; 2, articular cartilages continuous with periosteum; 3, disc; and 4, spaces lined with synovial membrane and containing synovial fluid.

second vertebræ, and *condyloid*, in which an oval head fits into a shallow elliptical cavity, as in the joints between the fingers and the hand.

Joints permit movements of the skeletal parts with each other. These movements are accomplished by means of the muscles and the kinds of movement are as follows:

FLEXION—Bending, as in raising the forearm on the arm.
EXTENSION—Straightening or unbending.
ABDUCTION—Moving away from the mid-line of the body.
ADDUCTION—Moving toward the mid-line of the body.
ROTATION—Turning on its own axis, as in turning the head.
PRONATION—Turning downward, as in turning the palm of the hand downward.
SUPINATION—Turning upward, as in turning the palm of the hand upward.
EVERSION—Turning outward.
INVERSION—Turning inward.

THE MUSCLES

Myology is the study of the structure and functions of muscles.

Muscles are structures composed chiefly of muscular tissue and all motion of any sort in the body, whether conscious or unconscious, is due to the action of muscles. They constitute a large part of the fleshy portions of the body, enter into the structures of many of the internal organs, form from 40 to 50 per cent of the body weight, and vary in shape according to the work they have to do.

All the muscles attached to the bones of the skeleton are of the voluntary type and are termed *skeletal muscles.* Those used in breathing, while ordinarily acting without conscious effort of the will, may be controlled and breathing accelerated, slowed, or stopped, as desired. A typical skeletal muscle consists of a fleshy mass of parallel bundles of muscle fibers bound together by a sheath of fibrous tissue called the *epimysium*, each bundle or fasciculus of fibers being surrounded by a delicate connective-tissue envelope called the *perimysium*, and each fiber being lightly covered by an elastic, connective-tissue sheath called the *sarcolemma.* At the ends of the muscle the epimysium and the perimysium unite with the tendons by which the muscle is attached to the bone. The attachment of a skeletal muscle which is fixed or stationary during use is known as the *origin* and the one which moves as the *insertion.* Many muscles have an insertion far from the fleshy belly.

Tendons are made up of closely packed, parallel bundles of nonelastic, dense fibrous tissue, with a very small amount of areolar tissue separating the bundles. They unite with the periosteum of bones to form secure attachments of muscles and differ in shape in different muscles, some being round and thick while others are flat and thin. When tendons are of the latter shape they are called *aponeuroses.* Their lack of bulk makes their presence about joints desirable as joint movements are easier accomplished than if bulky muscles were present.

Muscles seldom act alone and the performance of a very simple motion is usually due to the action of a whole group of muscles. Muscles and groups of muscles are named according to the type of motion they produce, as the *extensor* muscles of the hand, and the *adductor* muscles of the thigh, and for each group of muscles that produces one type of motion there is another group that produces the opposite type of motion. To keep muscles in position and place during movement they are held together by layers of areolar tissue called *fasciæ.*

The **fasciæ** vary in density, structure, and thickness, in some places forming considerable masses, and are of two types called *superficial* and *deep.* The superficial type lies immediately beneath the skin and usually contains considerable fat. Blood and lymph vessels and nerves of the skin are also found in

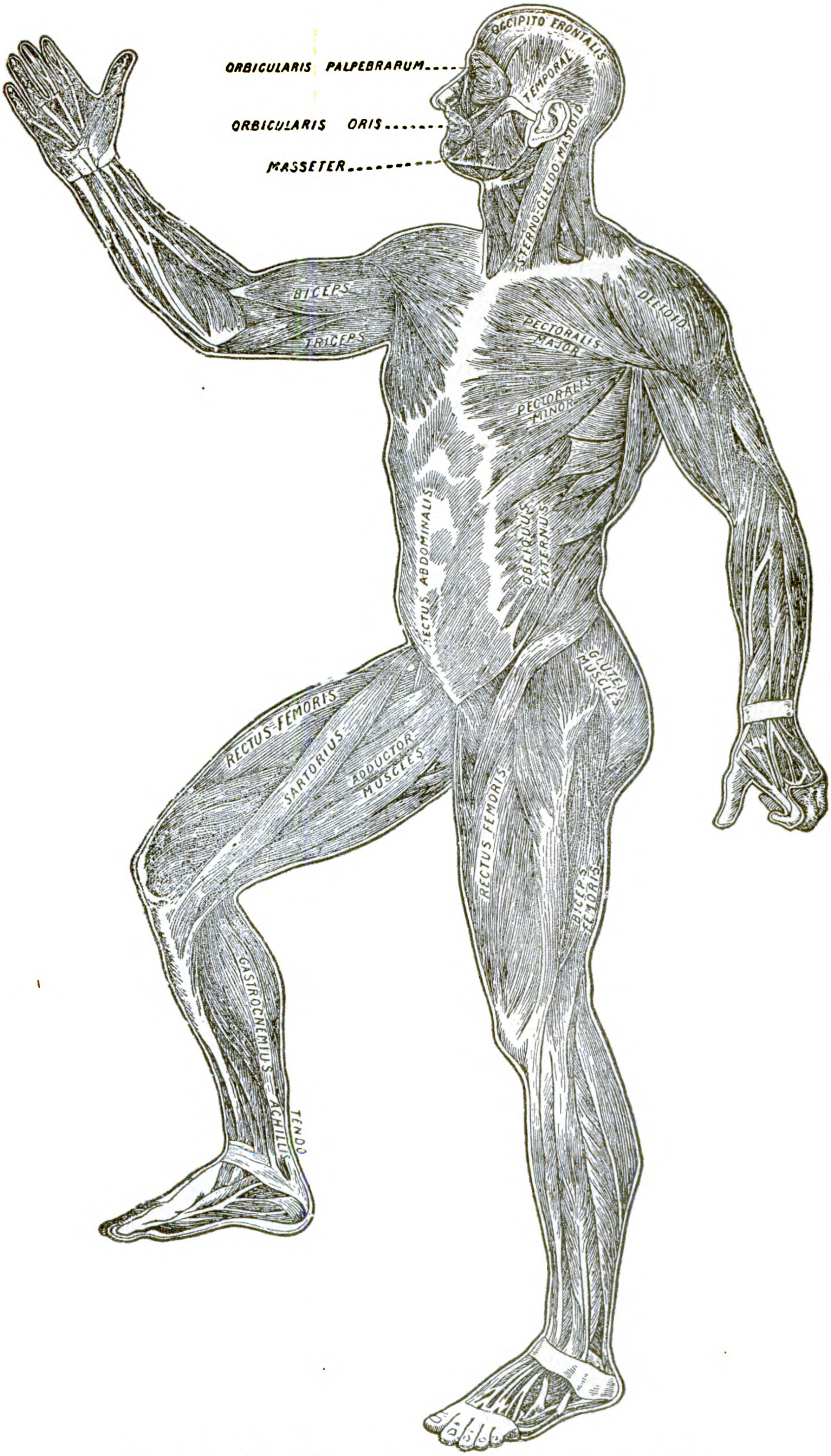


FIGURE 20.—Superficial muscles of the body. (After Brubaker.)

it. The deep type is dense and tough and in addition to covering muscles, covers delicate and specialized structures such as organs and blood vessels. In many places sheets of it lie between adjacent groups of muscles thereby permitting the different groups to act independently and still remain in place.

Each muscle has a nerve supply and it is usually through the action of its nerve that a muscle is brought into activity and its action coordinated with that of other muscles. Such a nerve is called a *motor nerve* and if one is destroyed by disease or injury the muscle usually becomes inactive and wastes away. In addition to the normal stimulation of muscles through their nerves, they may also be activated by mechanical, chemical, or electrical stimulation of the muscles themselves, and by the application of heat and cold.

When a muscle contracts it uses a certain amount of energy to do a certain amount of work. In doing this work the protoplasm in the muscle cells breaks down and chemical waste products, which are toxic, are produced. If these waste products accumulate the phenomena of fatigue result, and in some cases muscular cramps may occur. To supply the energy required and restore the muscle protoplasm, carbohydrates are taken from the blood and oxidized in the muscle. During contraction, or work, carbon dioxide and water are formed by oxidation, and removed by the blood which also brings the oxygen necessary for the restoration of muscle protoplasm. In ordinary activities the blood supply to muscles is increased, thereby increasing the supply of food materials, carrying away waste products more quickly, and enabling the muscles to build up and restore their efficiency.

When muscle substance dies it becomes solid and rigid, and loses its power to react to stimulation. The stiffening and hardening of the muscles after death is due to this phenomenon, which is called *rigor mortis.*

The muscles of the body are divided into the following groups: those of the head and face; of the neck; of the trunk, which is subdivided into those of chest, thorax, abdomen, back and perineum; those of the upper extremity; and those of the lower extremity (fig. 20).

The **muscles of the head and face** consist of numerous groups of small muscles which act in the movements of the eyes, the face, the scalp and assist in mastication, deglutition, talking and expression.

The **muscles of the neck** move the head from side to side, backward and forward, and rotate it. Some of these muscles act as auxiliary muscles of respiration, assist in deglutition, in speaking, and in other complicated movements of the head and neck.

The **muscles of the back** are divided into five layers, the superficial layer and four deep layers. They act on the spinal column to keep the trunk in an erect posture, and permit movements from side to side, forward and backward, and a moderate amount of turning. Those of the **chest and thorax,** including the **diaphragm,** the great muscle which separates the thoracic and the abdominal cavities, are chiefly respiratory muscles. These muscles, with the exception of the diaphragm, assist in movements of the trunk, the neck and the upper extremities. The **muscles of the abdomen** are the *external oblique*, the *internal oblique*, the *rectus abdominis*, and the *transversus abdominis.* The rectus abdominis is a paired muscle situated on each side of the median line of the abdomen within the fibrous aponeurosis of the oblique muscles. It extends from the symphysis pubis to the thoracic wall. These muscles form the sides and front of the abdominal wall. They assist in micturition and defæcation by compressing the abdominal visceræ. They also assist in respiration and emesis, flex the thorax on the pelvis and aid in lateral flexion and rotation of the spine.

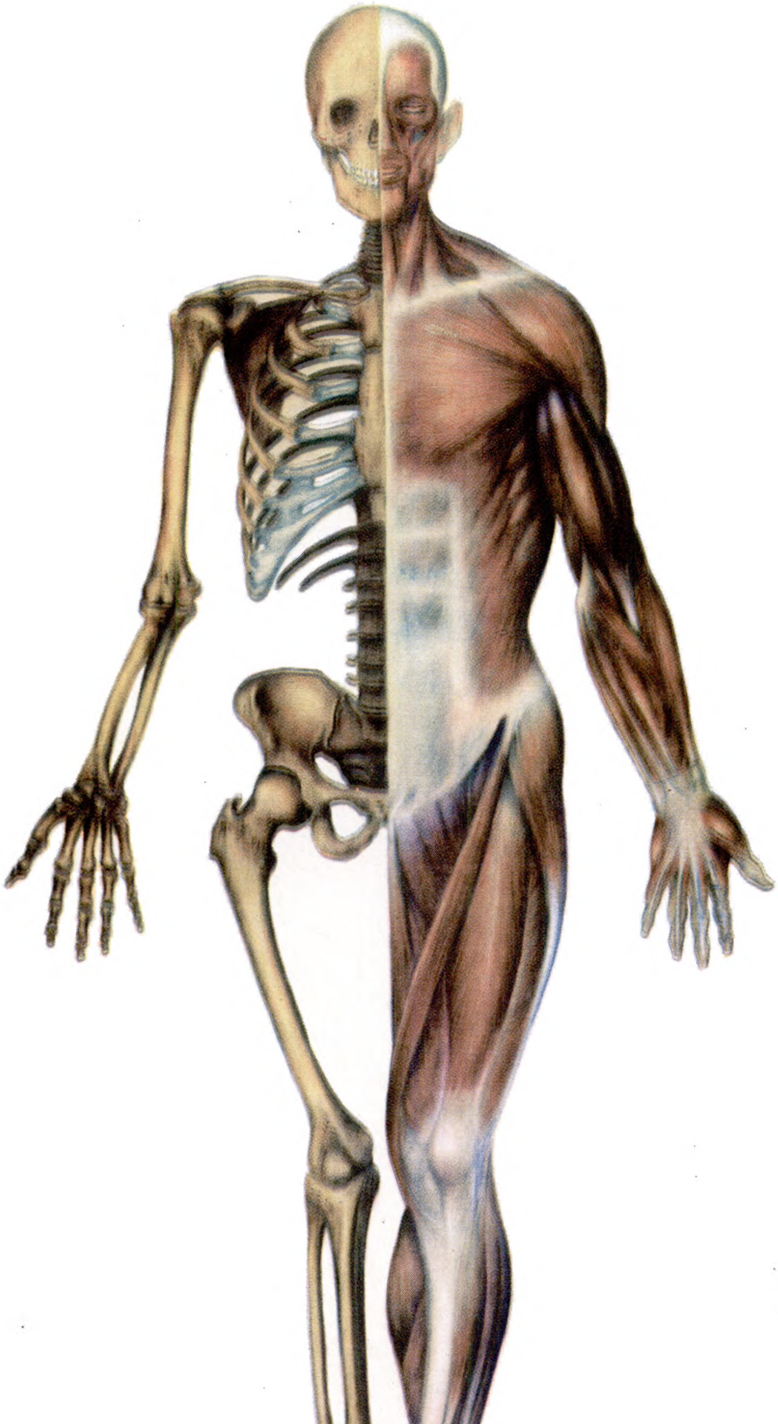


FIGURE 21.—ANTERIOR VIEW OF RELATION OF SKELETAL MUSCLES TO SKELETON
(U. S. NAVAL MEDICAL SCHOOL)

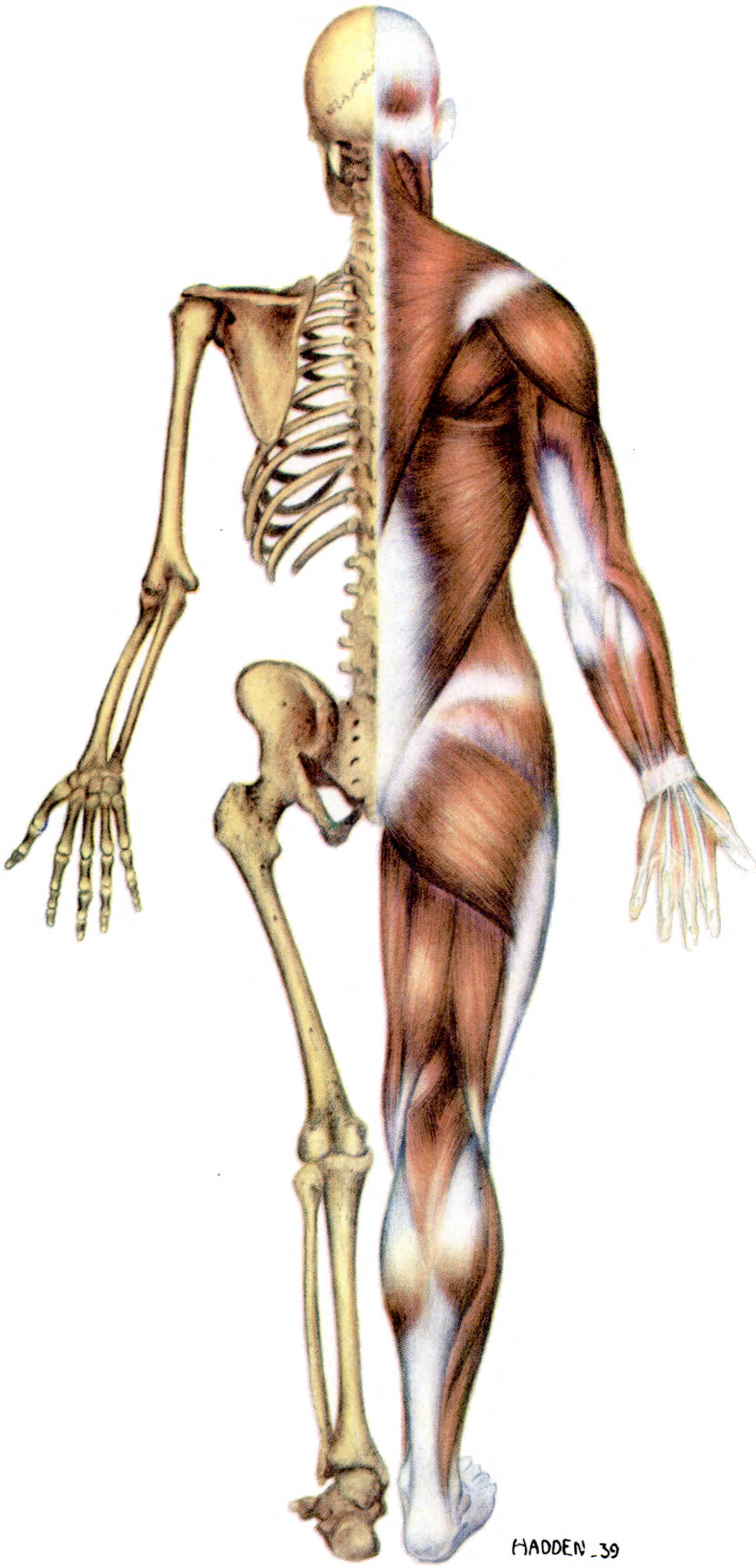


FIGURE 22.—POSTERIOR VIEW OF RELATION OF SKELETAL MUSCLES TO SKELETON
(U. S. NAVAL MEDICAL SCHOOL)

The **inguinal ligament** (Poupart's) is a thickened band of fibers of the aponeurosis of the external oblique muscle, extending from the anterior superior spine of the ilium to the spine of the pubis. Just above this ligament and parallel to it is the inguinal canal through which pass the spermatic cord in the male, and the round ligament of the uterus in the female. The inner opening in the transversus muscle is called the *internal inguinal ring;* the outer opening in the tendon of the external oblique muscle is called the *external inguinal ring.* These openings form weak places in the abdominal wall, and are the frequent sites of a protrusion of parts of the viscera which is called a *hernia* or rupture. Other weak places are the *umbilicus*, and the *femoral ring* which serves as a passage for the blood vessels to the lower extremity.

The **muscles of the perineum** are those surrounding the base of the reproductive organs and the rectum and form the floor of the pelvis. Their action is to assist in micturition and defæcation.

The **muscles of the upper extremity** are divided into those of the shoulder, which act to move that joint; those of the arm; those of the forearm; and those of the hand.

The muscles on the front of the arm flex the forearm; those on the back extend it. The same principle applies generally to the muscles which arise from the bones of the forearm and are attached to the bones of the hands or fingers. Some of these muscles however act to *pronate* the hand (turn palmar surface down) and others to *supinate* the hand (turn the palmar surface up). The muscles of the palm and the back of the hand, flex, extend, adduct, abduct and circumduct the fingers and the thumbs.

The **muscles of the lower extremity** are divided into those of the hip; the thigh; the leg; and the foot. The muscles on the anterior side of the hip flex the thigh on the abdomen, those on the posterior extend, those on the medial side adduct and those on the lateral side abduct. Combinations of these actions produce circumduction of the lower extremity.

The muscles of the posterior portion of the thigh flex the leg on the thigh. Those of the anterior portion extend the leg. The muscles having origin on the anterior surface and on the posterior surface of the bones of the leg, flex, extend, and circumduct the foot. The muscles of the dorsal and the ventral surfaces of the foot extend and flex the toes respectively.

It is not possible to present a complete study of the individual skeletal muscles in this chapter, but to show the way they should be studied a few that form important anatomical landmarks and typify the action of muscles in general will be individually described.

The **temporal muscle.**

Origin: From the whole area of the temporal fossa.

Insertion: The coronoid process of the mandible.

The muscle is fan-shaped, and its principal action is to close the jaw.

The **sternocleidomastoid muscle** is an important landmark in the neck and can be easily demonstrated by bending the head forward and to the opposite side.

Origin: The manubrium of the sternum and the medial third of the upper surface of the clavicle.

Insertion: The mastoid process of the temporal bone.

Action: When acting alone flexes head laterally and rotates it to the opposite side. Both acting together bend the head forward. (If muscles in the back of the neck hold the head extended they may act as extraordinary muscles of inspiration by raising the sternum and the clavicles.)

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The **biceps muscle** is located on the front of the arm.

Origin: By two heads, which accounts for its name. The tendon of the short head is attached to the tip of the coracoid process. The tendon of the long head is attached just above the upper rim of the glenoid cavity and passes through the capsule of the shoulder joint.

Insertion: By a tendon which attaches to the tubercle of the radius.

Action: Draws the arm forward, flexes the elbow, and supinates the forearm.

The **triceps muscle** is located on the back of the arm.

Origin: By three heads, hence its name; the long head from the scapula, the lateral head from the upper part of the humerus, and the medial head from the lower posterior surface of the humerus.

Insertion: By a tendon to the olecranon process of the ulna.

Action: To extend the elbow and to adduct the arm.

The **deltoid muscle** forms the prominence of the shoulder.

Origin: From the lateral part of the shoulder girdle.

Insertion: The outer surface of the shaft of the humerus at about its middle (the deltoid tuberosity).

Action: To raise (abduct) the arm.

The **diaphragm** is the muscular wall which separates the abdominal cavity from the thoracic cavity. It is vaulted upward. Its fibers arise from the bony cartilaginous chest wall, converge, and are inserted into the fibrous central portion. When the fibers contract they pull the central portion downward.

SPECIAL MEMBRANES AND GLANDS IN GENERAL

A **membrane** is an enveloping or lining tissue of the body. The chief membranes are classified as: *Serous, synovial, mucous* and *cutaneous.*

Serous membranes are thin, transparent, fairly strong and elastic. Their surfaces are moistened by a fluid resembling serum. They are found lining closed cavities and passages which do not communicate with the exterior. These membranes consist of two layers; the *endothelium*, a modified epithelium, and the *corium*, a thin layer of fibrous tissue and blood and lymph vessels. They are divided into the following three classes:

Serous membranes proper, which consist of a closed sac, one part of which is attached to the walls of the cavity which it lines, and the other reflected over the surface of the organs contained in that cavity. This class includes the *pleuræ*, which cover the lungs and line the thoracic cavity; the *pericardium* which covers the heart; the *peritoneum* which lines the abdominal wall, and clothes its contained viscera; the *lining membrane of the vascular system;* the *internal coat of the heart, blood vessels and lymphatics;* the *capsule of Tenon,* back of the eyeball; and the *arachnoid coat of the meninges.* The serous membranes serve as a protective covering by forming a smooth slippery lining and secreting a serum which acts as a lubricating fluid.

Synovial membranes are associated with joints and muscles and secrete a viscid glairy fluid called *synovial* or *joint fluid.* These membranes are *articular,* which surround and lubricate the joints; *vaginal,* which form the sheaths of tendons about some joints; and *bursal,* which form simple sacs interposed between soft tissue and bone. The latter may be deep seated between muscle or tendon and bone, or superficial between skin and bone, for example, the patellar bursæ.

Mucous membranes line the cavities which communicate with the exterior. Their surfaces are coated over and protected by mucus. The mucous membranes of the body may be divided into the gastro-pulmonary, and the genito-urinary.

The *gastro-pulmonary mucous membrane* covers the inside of the alimentary tract and the air passages and all cavities communicating with them. This includes the accessory sinuses of the nose; the lacrimal ducts; the conjunctiva; the auditory canals, including the middle ear and the mastoid cells; the common bile duct; the gall bladder; the biliary ducts; the pancreatic duct; and the salivary ducts. The *genito-urinary mucous membrane* furnishes the inside lining of the urethra; the bladder; the ureters; the pelvis and tubules of the kidney; and all of the genital ducts including the prostatic, the seminal and the ductus deferens.

Cutaneous membrane is the external covering of the body, or skin. Its structure and functions will be discussed later.

A **gland** is an organ which secretes something essential to the system or excretes waste materials the retention of which would be injurious to the body.

Glands are of three types: Simple, compound, and ductless. *Simple glands* are generally tubular or sacular in structure and open to the surface by a single duct, their secretions being thrown directly onto a free surface. *Compound glands* are glands the structure of which is subdivided into smaller tubular or sacular structures which open by smaller ducts into a main duct. Their structure may be compared to a bunch of grapes, the branching stem of which corresponds to the ducts of the gland and the grapes to the groups of gland tissue called *lobules*. The secretions of compound glands are carried off through their ducts. *Ductless glands* are glandular structures which have no ducts and whose secretions are discharged directly into the blood or lymph.

THE BLOOD AND THE BLOOD VASCULAR SYSTEM

Blood is the fluid tissue which is contained and circulates in the *blood vascular system* of the body. This system consists of the heart, arteries, capillaries, and veins, and in it the blood is kept circulating by the force of the heart beat. In the adult the quantity of blood is estimated to be about one-thirteenth of the body weight or about 6 quarts in an average adult weighing 160 pounds. It is a reddish colored, viscid, opaque fluid slightly heavier than water, normally having a specific gravity averaging about 1.055 and a slightly alkaline reaction. In composition blood consists of a fluid portion, the *plasma* or *blood plasma*, in which are suspended the "formed elements," the *red blood cells*, the *white blood cells*, and the *blood platelets*. The blood cells are also known as blood *corpuscles* and the blood platelets as *thrombocytes*. In blood the cells are not joined together by intercellular substance as in other tissues but float freely in the plasma.

The functions of the blood are numerous and all are important and necessary to the well-being of the body. In performing its functions blood:

1. Serves as a medium for the exchange of gases, carrying oxygen to the tissue cells and removing carbon dioxide from them;
2. Serves as a medium for the interchange of nutritive and waste materials, carrying food materials absorbed from the digestive tract to the tissue cells and removing waste materials from them for elimination by the excretory organs;
3. Serves as a medium for the transmission of hormones;
4. Aids in equalizing and maintaining body temperature;
5. Aids in protecting the body against infection by contributing cellular and body-fluid factors to the defense mechanism of the body known as immunity;
6. Guards against hæmorrhage by clotting when shed; and
7. Maintains the all-important acid-base equilibrium or balance of the body.

Healthy blood (plasma and blood cells) consists of about 78 per cent water and 22 per cent solids, and contains a great variety of substances, most of which are found in the plasma.

Blood plasma is the fluid portion of the blood and when free from blood cells is a clear, straw-colored liquid having a specific gravity of about 1.026 and a slightly alkaline reaction. The term blood plasma should not be confused with the term blood serum for the two terms refer to quite different substances. Blood plasma is the liquid part of blood *before* coagulation takes place. When blood escapes from its vessels it usually coagulates, or clots, and as the clot forms it generally shrinks and squeezes out a clear, yellowish liquid known as blood serum, which may be defined as the liquid part of blood *after* coagulation takes place. By filtration the plasma passes through the walls of the capillaries into the tissues where it is known as *lymph.*

The composition of blood plasma is about 90 to 92 per cent water and about 8 to 9 per cent solids. In addition to water its constituents may be listed as follows:

1. Gases: Oxygen, carbon dioxide, and nitrogen;
2. Proteins: Fibrinogen, globulins, albumins, and cell proteins, excluding hæmoglobin;
3. Pigments: Hæmoglobin, in red blood cells, bilirubin, in serum, etc.;
4. Nonprotein nitrogenous bodies: Urea, uric acid, creatine, creatinine, amino acids, ammonium salts, and an unidentified fraction;
5. Nonnitrogenous bodies: Sugar, lactates, phenols, chlolesterol and "lipoids" such as fats, soaps, and the phosphatides (phospholipoids); together with the intermediate products of fat metabolism ("acetone bodies");
6. Inorganic salts: The chlorides, carbonates, sulfates, and phosphates of sodium, potassium, calcium, magnesium, and iron;
7. Enzymes and antienzymes: Glycolase, lipase, enterase, oxidase, antiprotease, etc.; and
8. Special substances: Hormones, immune bodies, opsonins, complement, etc.

Acid-base equilibrium.

The normal metabolic processes of the body result in the continuous production of acid end-products which tend to alter the reaction of the blood when added to it, i. e., make it less alkaline. Oxidation in all tissues produces carbon dioxide which has acid properties, muscular activity produces lactic acid, and sulfuric and phosphoric acids are formed in the oxidation of proteins containing sulfur and phosphorus. In spite of such acid substances being constantly added to the blood its slightly alkaline reaction remains remarkably uniform and constant because the physiological activities of the body are so adjusted that variations in the reaction are kept within narrow limits. The maximum variation in reaction that is not dangerous to life is only eight-tenths of a point. Keeping the alkaline reaction of the blood within those limits is known as *maintaining the acid-base equilibrium* or *balance* and is accomplished by neutralization of the acid products as soon as they are formed in the tissues, by the prompt elimination of excess acid through the regulating action of the lungs and kidneys, and by the presence in the blood of substances called *buffers.*

A buffer is any substance which when present in a solution tends to prevent the reaction of the solution from changing on the addition of acid or alkali. All buffers are mixtures of a weak acid and its basic salts, or a weak base and its acid salts, and among the substances present in the blood which act as buffers carbonic acid and its bicarbonate salts and hæmoglobin and its basic salts

are of chief importance; proteins in the plasma have some buffer action, and also the phosphates.

The action of buffers in maintaining the acid-base equilibrium is a very complicated process and only a brief explanation can be given here. This action, which is spoken of as *buffering,* depends on the presence of substances in the blood and tissues which convert strong acids into weaker ones by chemical reaction. One of these substances is sodium, an alkali, which reacts chemically with weak acids such as carbonic acid and phosphoric acid, and with proteins to form the alkaline salts sodium bicarbonate, sodium phosphate, and the sodium salts of the proteins. These salts in turn react with stronger acids to form sodium salts of the stronger acids and at the same time liberate the weaker acids. In this way the effect of the stronger acids is greatly weakened and there is prevented an increase in acidity which would tend to make the reaction of the blood less alkaline.

The combination of sodium with a weak acid, mainly as sodium bicarbonate, constitutes the principal buffering mechanism of the blood, and the amount of sodium that is so combined and available for use in neutralizing stronger acids is spoken of as the *alkali reserve.*

The principal acid added to the blood as the result of the metabolic processes in the body is carbonic acid, considerable of which is formed when carbon dioxide enters the blood from the tissues. As soon as this acid is formed most of it combines with the sodium chloride present in the blood plasma and forms sodium bicarbonate, the remainder diffuses into the red blood cells where it unites with the potassium present as potassium hæmoglobinate and forms potassium bicarbonate. The chlorine liberated in the formation of sodium bicarbonate passes to the red blood cells where it combines with the hæmoglobin. The result of these reactions is an increase in the amount of bicarbonates available for the neutralization of acids.

On reaching the lungs the blood becomes oxygenated or purified and the hæmoglobin gives up the chlorine it had taken up. The liberated chlorine passes into the blood-plasma, reacts with the sodium bicarbonate to form sodium chloride and liberates carbon dioxide which is exhaled. Should there be any tendency toward an increase in the acidity of the blood such as would follow an increase in carbon dioxide the respiratory center is stimulated and respiration becomes more rapid with consequent increased elimination of carbon dioxide.

As the neutralization of acids cannot be accomplished without lowering the alkali reserve and as acids are constantly being added to the body in foods and by the acids formed within the body, to prevent lowering the alkali reserve to a point where it is dangerous it is necessary to eliminate the acids without losing a corresponding amount of alkali, or base. This is largely done through the secretory and excretory functions of the kidneys, which play an important part in maintaining the normal acid-base balance or equilibrium of the blood by excreting the excess of acids above the normal equilibrium.

The normal acid reaction of urine as compared with the slightly alkaline reaction of blood is due to the selective ability of the kidneys to excrete weak acids and acid salts and at the same time hold back a large part of the alkali base with which they are combined in the blood. The part which is held back is used to replenish the alkali reserve. Acid elimination takes place through the kidneys principally in the form of acid phosphates, and in some conditions as much as 50 per cent of the acid excreted may be free acid. Should the alkali base begin to be depleted in spite of this excretion of acid the kidneys break up urea which is accompanied by the production of ammonia.

The ammonia so formed is then used instead of alkali base to neutralize much of the acid excreted which appears in the form of ammonium salts. Even strong acids like hydrochloric and sulfuric are sometimes excreted as ammonium salts.

This neutralizing mechanism may be so overtaxed or its activities so disturbed by the ingestion of unusual amounts of acid or alkali or as a result of disease that there occurs a noticeable change in the reaction of the blood and resulting conditions known as *acidosis* or *alkalosis*. Any marked change of reaction is fatal unless quickly corrected or compensated.

Acid-base equilibrium or balance is also discussed in the section on Laboratory Procedures and Technique.

Immunity.

The body possesses a defense mechanism termed *immunity* by which it can resist and overcome infection. (*See* section on Hygiene and Sanitation.) By immunity is meant the ability of the body to protect itself against injury by harmful bacteria or by the poisonous products of bacteria called *toxins*. In this defense mechanism the blood and lymph play an important part. The protective function of the blood in immunity is partly due to the blood plasma and partly to the white blood cells.

Any substance which, when injected into an organism, is capable of stimulating the production of a substance antagonistic to the substance injected is known as an *antigen*, and the substance produced is known as an *antibody*. When foreign substances such as bacteria or their toxins enter the blood they act as antigens and stimulate the production in the blood plasma of specifically antagonistic antibodies. There are various types of antibodies and they are usually designated according to the manner in which they act against the invading substance. Some of the more important types are known as *bacteriolysins*, which kill the bacteria themselves, *agglutinins*, which cause the bacteria to settle together in clumps, *precipitins*, which cause precipitation of the bacteria, and *antitoxins*, which neutralize the poisons produced by bacteria.

Also produced in the blood plasma are substances called *opsonins* which so change bacteria that they can be more easily ingested by the white blood cells.

Through their power of amœboid movement the white blood cells are able to surround bacteria and ingest and destroy them. Often the white cells are themselves destroyed and the dead ones may be removed by other cells. When killed in large numbers the white cells form a large part of the solid or semisolid matter called *pus* that is found in an abscess.

Transmission of hormones.

The glands of internal secretion, commonly called ductless glands, produce substances termed internal secretions or *hormones* which play a most important part in body functions. Because these glands have no ducts their secretions are absorbed into the blood through the walls of the capillaries present in the substance of the glands and are then carried by the blood to the parts of the body where their action or effect is to be produced.

As a rule the ductless glands are not located near the organs with which they are functionally associated and consequently the hormones may be carried considerable distances in order to produce their effects. Some hormones which have a more or less general systemic action are continually carried to all parts of the body.

By this distribution of hormones the blood serves as a means of providing the coordinated function and harmonious working of the body so necessary to its well-being.

Blood coagulation.

One of the most striking properties of blood is its power to coagulate or clot. Undisturbed blood circulates in the blood vascular system of the healthy body without showing any tendency to clot, but on escaping from the blood vessels it normally begins to clot immediately. Clotting is the body's method of preventing excessive loss of blood in the unavoidable injuries met with in ordinary life.

In the process of clotting both physical and chemical factors are involved. When blood escapes from blood vessels it leaves its natural environment and its normal physical state is changed by exposure to changes in temperature, by changes in its gas and acid-base balances, and by contact with objects foreign to its natural surroundings such as air and the skin. The chemical factors are those having to do with the formation of the clot.

The blood which forms a clot is at first perfectly fluid but soon becomes viscous and then "sets" into a soft jelly which quickly becomes firm enough to act as a plug. The clot becomes more compact and gradually shrinks in volume, at the same time squeezing out blood serum. The essential part of the clot is an insoluble protein substance called *fibrin* which is not present in normal blood but is produced from substances in the blood plasma, blood cells, and tissues when formation of a clot is necessary.

Among the protein constituents of the blood plasma was named *fibrinogen* which is the essential chemical factor in the formation of fibrin. Fibrinogen is a protein of the globulin type probably produced in the liver, and by itself is inert or inactive. In the generally accepted theory of clotting, when fibrinogen comes in contact with *thrombin*, a so-called fibrin ferment formed from *prothrombin* (or *thrombogen*) by the action of calcium salts, they interact and fibrin formation occurs. For prothrombin to be converted into thrombin by the action of calcium salts a third substance known as *cephalin* (or *thrombokinase*) must be present. This substance, called a thromboplastic agent, neutralizes the substance *heparin* which ordinarily prevents the activation of prothrombin, and is released from the injured tissues and from blood platelets which quickly disintegrate when exposed to air.

As fibrin is formed fine threads, fibrils, or needles of it traverse the escaping blood in various directions and encircle groups of blood cells. The meshes of this fibrin network draw closer together, the cells are packed more tightly together, blood serum is squeezed out, and a clot or *coagulum* is formed.

The process of clotting may be expressed diagrammatically as follows:

$$\begin{array}{ll} \text{Cephalin} \longrightarrow & \text{Prothrombin} + \text{Calcium salts} = \text{Thrombin} \\ \quad\downarrow & \text{Thrombin} + \text{Fibrinogen} = \text{Fibrin} \\ \text{Heparin} & \end{array}$$

The formation of a clot closes the opening of wounded blood vessels and prevents great loss of blood. A clot also closes the opening in a wound and is the basis for the growth of new tissue in the process of healing. The clotting power differs in different individuals and normally 3 to 5 minutes is sufficient time for a clot to form, but in rare cases even trivial wounds may cause severe and dangerous bleeding. The condition in which clotting of the blood is delayed is known as *hæmophilia* and a person having this condition is known as a *hæmophiliac.*

The formed elements of the blood.

Red blood cells, or *erythrocytes*, are circular, biconcave discs or bodies without a nucleus that give to the blood its characteristic color (fig. 23). They are about 1/3200 of an inch in diameter and in the adult male number about 5,000,000

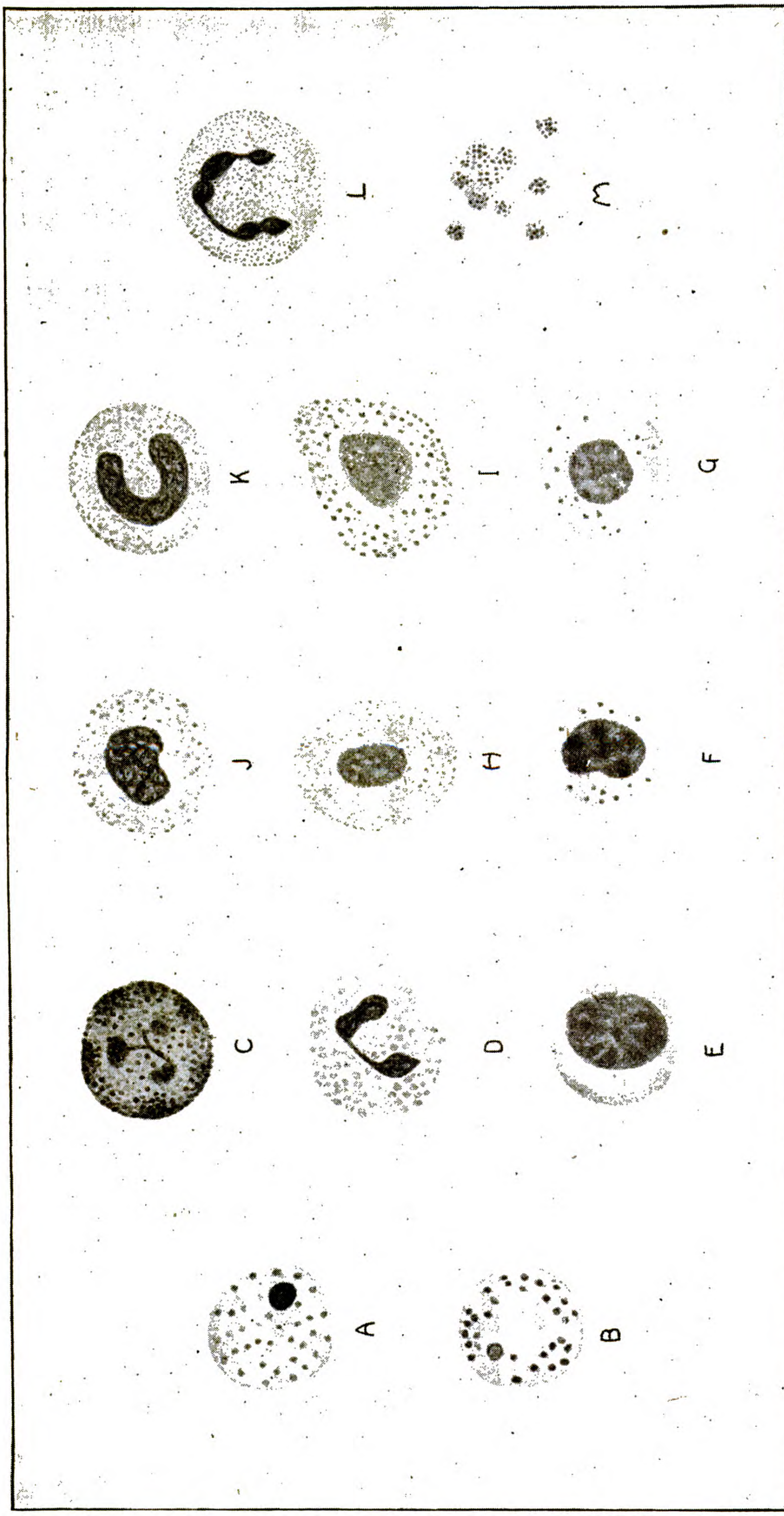

FIGURE 23.—Types of blood cells: *a* and *b*, red blood cells; *c*, polymorphonuclear basophile; *d*, polymorphonuclear eosinophile; *e* and *f*, small lymphocytes; *g*, large lymphocyte; *h*, neutrophilic myelocyte; *i*, primitive type of myelocyte; *j* and *k*, monocytes; *l*, polymorphonuclear neutrophile; *m*, clump of normal platelets. (Stitt, Clough, and Clough, modified.)

per cubic millimeter of blood. Their red color is due to the presence in them of *hæmoglobin*, a substance composed of an iron salt and a protein and which has the power of combining easily with oxygen to form *oxyhæmoglobin*, a loose chemical combination of oxygen and hæmoglobin by which oxygen is carried from the lungs to the body tissues. Hæmoglobin also possesses the power of readily combining with carbon dioxide and carries it from the tissues to the lungs. The affinity of oxygen and carbon dioxide for hæmoglobin depends upon the concentration of these gases at the point of exchange. In the lungs, oxygen being at a greater concentration than carbon dioxide, the hæmoglobin exchanges its carbon dioxide for oxygen and forms oxyhæmoglobin, but in the body tissues carbon dioxide is at a greater concentration than oxygen and the hæmoglobin exchanges its oxygen for carbon dioxide forming *carb-hæmoglobin*. In the adult, red blood cells are reproduced in the red marrow of bone. The cells there produced have a nucleus which they lose before entering the blood stream. A large number of red blood cells are destroyed daily, in what manner it is not definitely known. It may take place in the liver, the spleen, or in the lymph nodes, and it is probable that many are broken to pieces by the buffetings they receive in the circulation. It is known, however, that a certain amount of hæmatin, a decomposition product of hæmoglobin, is excreted in the bile, a fact which apparently substantiates the belief that some red blood cells are destroyed in the liver. Red blood cells depend upon the percentage of salt or sodium chloride present in the blood plasma for the maintenance of their form. Normally the amount of salt is equivalent to about a nine-tenths of 1 per cent solution of sodium chloride which fluid is isotonic or has the same osmotic pressure as the tissue fluids. If the percentage of salt is less the red cells will absorb water, swell, and burst, and their hæmoglobin is discharged. This is called *hæmolysis* and it may be caused by certain bacterial products called *hæmolysins*. If the percentage of salt is above the normal, water is extracted from the red cells and they shrivel or become *crenated*. These facts must be remembered in intravenous medications.

In the human being the color of the blood in the arteries is bright red, because the hæmoglobin in it is combined with oxygen, or is oxygenated; in the veins the color of the blood is dark red because the hæmoglobin has given off its oxygen and exchanged it for carbon dioxide.

White blood cells, or *leucocytes*, are nucleated blood cells and vary in size and shape (fig. 23). They are, in fact, almost colorless, are somewhat larger than red cells, and number about six to eight thousand per cubic millimeter of blood under normal conditions. This number may increase for various reasons and such an increase is called *leucocytosis*. Certain pathological conditions such as acute infections, malignant growths, poisonings, etc., usually cause an increase in the number of white cells. When the number of white cells drops below the normal standard the condition is known as *leucopenia* and is found in certain uncomplicated infections, poisonings, debilitations, etc.

The principal function of the white cells is to combat disease. This they do by contributing to the formation of antibodies and by ingesting and destroying bacteria, a process called *phagocytosis*. They also aid in the absorption of digested fat and proteins, and in the clotting of blood. Leucocytes have the striking property of amœboid movement which enables them to alter their shape, ingest and destroy bacteria, and to move themselves and pass through the walls of blood vessels into the surrounding tissues. This passing into tissues is known as *migration* and is one of the phenomena of inflammation.

White blood cells are divided into three distinct groups known as *granulocytes, lymphocytes,* and *monocytes,* which differ from one another in origin, structure, and function. There are three varieties of granulocytes called *neutrophiles, eosinophiles,* and *basophiles,* all of which are *polymorphonuclear* (having more than one irregularly shaped nucleus). Lymphocytes are known as *large* and *small.*

When stained for microscopical examination and differential counting, white blood cells show many variations of color in the nucleus and cytoplasm, and it is by these variations that the different kinds of white cells are recognized. When a differential count made in acute infections shows an increase in the percentage of immature white cells it is considered roughly proportional to the severity of the infection. Such an increase of immature white cells is due to the fact that infections promptly cause a demand for additional white cells to combat the infecting organism and as the reserve supply of mature or fully formed white cells is relatively small the demand for the increase is met by the production of new cells, many of which enter the circulation before their development is completed.

Blood platelets, or *thrombocytes,* are round or oval bodies in the blood that consist only of cytoplasm (fig. 23). They vary greatly in size and shape, have no nucleus, are smaller than red blood cells, and number from 300,000 to 800,000 per cubic millimeter of blood, according to the method used to count them. They are an essential element in blood coagulation or clotting, mixing with fibrin to form a firm clot, and are believed to be fragments of the cytoplasm of multinuclear giant cells of the bone marrow (*megakaryocytes*) that have been pinched or broken off.

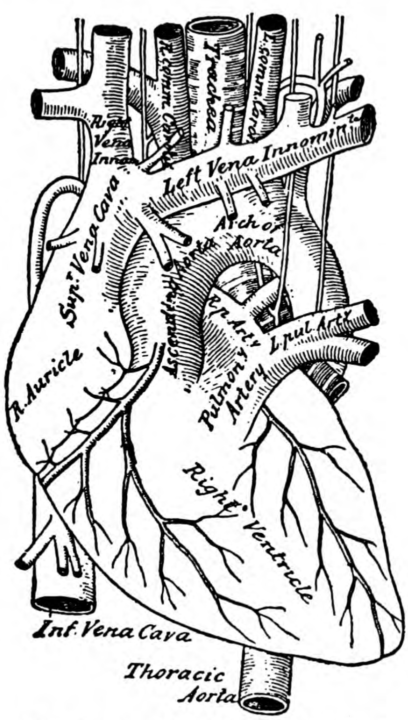

FIGURE 24.—The heart. (Mason.)

The blood-vascular system.

The organs of the blood vascular system are the heart, the arteries, the capillaries, and the veins. These form a closed system of tubes called *vessels* through which the blood circulates and reaches all parts of the body, and a muscular pump which propels the blood through the vessels.

The **heart** is a hollow, muscular organ located in the front and center of the thoracic cavity of the chest, between the lungs, with a large part of it lying directly back of the sternum or breast bone. It is about the size of a closed fist and closely resembles a strawberry in shape. The *base* of the heart points upward, backward, and to the right, and the pointed end, or *apex,* points downward, forward, and to the left (fig. 24).

The heart is enclosed in an inverted sac of fibro-serous membrane called the *pericardium,* the inner layer of which adheres closely to the musculature of the heart. The outer surface of the pericardium turns back over the inner layer and forms a cavity which contains a small quantity of fluid known as the *pericardial fluid* that lubricates the surfaces of the pericardium and prevents

friction during the movements of the heart. The inside of the heart is lined with a delicate serous membrane called the *endocardium.*

The main portion of the heart is composed of muscular tissue called the *myocardium.* This muscular tissue is of a type found only in the heart, being striated or striped, but involuntary. Some of the muscles of the heart run transversely, others longitudinally, others obliquely, while those in the apex make a spiral turn or twist. This intricate arrangement makes possible an even and complete closing of the heart cavities during contraction.

The interior of the heart is completely separated into right and left halves by a longitudinal muscular septum, and each half is divided into an upper, receiving chamber, the *auricle,* and a lower, ejecting chamber, the *ventricle.* Consequently, there are four cavities in the heart. Each auricle communicates with its corresponding ventricle by means of an oval aperture called the *auriculo-ventricular* opening or valve. During fœtal life there is an opening between the auricles of the heart known as the *foramen ovale,* which, however, closes immediately after birth. The walls of the auricles are much thinner than those of the ventricles and the wall of the left ventricle is much thicker than that of the right ventricle. This difference in development is because the ventricles perform a greater amount of work than the auricles and the left ventricle performs more work than the right.

Each of the four cavities of the heart is lined with endocardium which, by folding back upon itself, forms the *valves* of the heart. These valves allow the free passage of blood in the proper direction but effectually prevent its return. The valves differ in the number and shape of the *cusps* or *segments* of which they are made and are named according to the number and shape of the cusps, or the openings which they guard. The right *auriculo-ventricular valve* is also known as the *tricuspid valve* from the fact that it has three triangular-shaped cusps; the left *auriculo-ventricular valve* is also known as the *bicuspid* or *mitral valve* from its two triangular-shaped cusps. Both the *pulmonary valve* and the *aortic valve,* opening respectively into the pulmonary artery and the aorta, have three half-moon-shaped cusps because of which they are known as *semilunar valves.*

The heart is nourished by blood supplied to it through the right and left *coronary* arteries and its nerve supply is from the pneumogastric nerve and the sympathetic nervous system. The central nervous system can control and regulate the rhythmical, automatic contractions of the heart which are continuous during life but it has nothing to do with the cause of those contractions, whose origin is not definitely known.

The heart action consists of wave-like contractions, beginning in the auricles and passing to the ventricles, followed by dilatations. These contractions and dilatations are alternate and continuous and occur normally at the rate of about 72 per minute, although this rate varies according to age, sex, exercise, temperature, and in some pathological conditions. Contraction, or *systole,* as it is called, is a period of work; dilatation, or *diastole,* is a period of rest or relaxation.

The time from the appearance of any feature of heart action to the appearance of that feature again is known as a complete *cardiac cycle,* during which blood is received into and ejected from the heart cavities. The events occurring in the heart during a single cardiac cycle and which show how the heart acts are here summarized. Ejection of blood from the ventricles having been completed, the ventricles quickly relax from the contraction which ejected the blood and the semilunar valves in the ventricles close. The auriculo-ventricular valves have been closed since the last filling of the ventricles with

blood and the auricles are now being steadily filled with blood from the large veins entering them while the ventricles are relaxed or resting. During this period of relaxation all the valves in the ventricles are closed and the ventricles are completely shut off on both sides for a short time. By the time the relaxation of the ventricles is complete the pressure of blood in the auricles has caused the auriculo-ventricular valves to open and from then until the beginning of the brief auricular contraction blood from the large veins entering the auricles is flowing into and filling both the auricles and the ventricles. Soon the ventricles become more tense as the quantity of blood in them increases, the auriculo-ventricular valves float into position for closing, and the auricular contraction begins. At the end of the brief contraction of the auricles a sudden wave of blood is sent into the ventricles, completely filling them, the auriculo-ventricular valves close, and contraction of the ventricles begins, with the ventricles again being shut off momentarily due to all their valves being closed. The increasing pressure of the blood from the ventricular contraction causes the semilunar valves to open and blood is forced into the large arteries opening from the ventricles as long as the contraction lasts.

The action of a normal heart produces two distinct sounds which may be heard by applying the ear to the chest. One is a long, booming sound caused when the auriculo-ventricular valves close and the ventricles contract; the other is a short, sharp sound, attributed to the closing of the semilunar valves.

Arteries are hollow, elastic tubes that carry blood away from the heart. They have a certain amount of rigidity and consist of three layers, an inner lining of vascular endothelium, a middle muscular layer composed of involuntary muscle tissue and elastic fibrous tissue, and an outer fibrous-tissue coat. Arteries have a nerve supply from the sympathetic nervous system by which the size of the passage-way in the arteries may be dilated or constricted. The smaller divisions of arteries are called *arterioles.*

Capillaries are minute, hair-sized vessels through which the blood passes from the arteries to the veins. They have very thin walls of endothelium only, communicate with each other, and form a dense, interlacing network in all parts of the body. In passing through the capillaries the blood gives its nutritive materials to the tissues and takes from the tissues the various waste products that are to be carried away, the exchange taking place through the very thin walls of the capillaries.

Veins are hollow collapsible tubes that carry blood to the heart. Their structure is similar to that of the arteries but their walls are much thinner, the middle layer containing less muscular tissue and elastic fibrous tissue. In many of the veins there are *semilunar valves* in pairs which act to prevent the backward flow of blood. They begin as minute *venules* formed from capillaries which have joined together.

In tracing the circulation of the blood (Fig. 25) it is necessary to begin at and return to a given point. In this case the given point will be the right auricle where venous, or impure, blood is entering from the *inferior* and *superior venæ cavæ.* This venous blood passes from the right auricle through the right auriculo-ventricular opening past the tricuspid valve, into the right ventricle. When the right ventricle contracts the tricuspid valve closes and the blood is forced past the pulmonary semilunar valve into the *pulmonary artery.* This artery divides into two branches, one going to each lung where it subdivides into smaller arteries, arterioles, and capillaries which surround the *alveoli*, or air sacs, of the lungs. During its circulation in the lungs the blood becomes aërated and is returned through small vessels to the four pulmonary veins, two from each lung, which empty into the left auricle. From

the left auricle the blood passes through the left auriculo-ventricular opening past the bicuspid or mitral valve into the left ventricle where, upon contraction of this part, it is discharged past the aortic semilunar valves into the aorta. From the aorta the blood flows through its branches, the arteries, and the arterioles, to the capillaries in every part of the body. The blood is returned by the capillaries to the veins and finally reaches the right auricle through the venæ cavæ.

The contraction of the left ventricle, forcing the blood into the arteries, causes a wavelike expansions of the arteries which is synchronous with a heart beat. This is called the *pulse*, and may be felt at certain points where the arteries approach the body surface. The most common location is where the *radial artery* passes over the distal end of the radius, in each of the upper extremities.

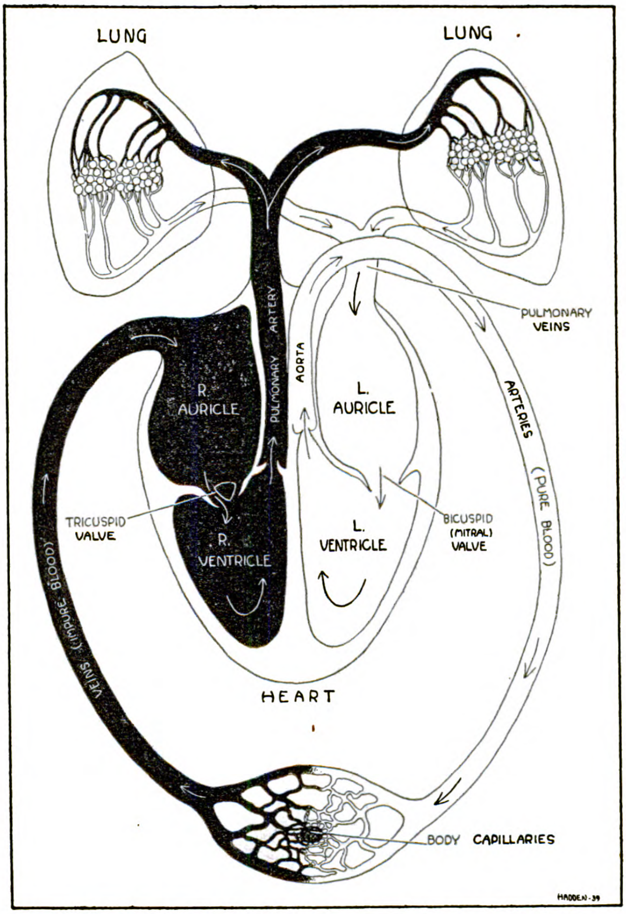

FIGURE 25.—Schema of circulation of the blood. (American Red Cross, modified.)

Blood pressure is the force of the blood exerted against the walls of the vessels in which it is contained. Although the term includes the pressure in the arteries, veins, and capillaries, the usual application of the term is to arterial pressure alone. The highest pressure—that is, that produced by the forceful propulsion of the blood through the arteries at each contraction of the ventricle—is known as the *systolic blood pressure.* Under normal conditions in the young adult this pressure is equivalent to about 120 millimeters of mercury, but varies as to age, sex, and condition of arteries and heart. Roughly, systolic blood pressure equals 100 plus the age of the individual. A certain amount of blood pressure is maintained in the arteries during the period of cardiac relaxation. This is caused by the elasticity and tonicity of the arteries and by the peripheral resistance. This pressure is known as the *diastolic blood pressure.* In normal young adults it is equivalent to from 70 to 90 millimeters of mercury. The difference between these pressures is called the *pulse pressure.*

The blood vessels.

The system of arteries and arterioles may be compared to a tree with the trunk giving off main branches which divide and subdivide again and again

until they are but minute twigs. The arteries are constantly carrying a pulsating stream of blood which leaves the arterial tree at the finest subdivision and passes into the network of capillaries. In many locations in the body arteries that arise from different sources join together to form a union called *anastomosis*, a good example of which can be found in the palm of the hand. In case some important artery is injured these anastomoses provide a *collateral circulation* that furnishes the necessary blood supply. The main trunk of the arterial tree is the *aorta* with which the discussion of the arteries will begin.

The **aorta** arises from the left ventricle of the heart, ascends a short distance, arches backward above the root of the left lung, and descends along the spinal column through the diaphragm to terminate at the level of the fourth lumbar vertebra by dividing into the right and left common iliac arteries. During its entire course the aorta is a continuous single trunk which gradually diminishes in size and gives off branches at various points. The portion of the aorta which is situated in the thorax is commonly called the *thoracic aorta* and consists of the ascending, the arch, and part of the descending aorta; the remaining portion is called the *abdominal aorta*.

The **ascending aorta**, a short part 2 to 2¼ inches long and contained within the pericardium, gives off two branches, the right and the left *coronary* arteries which supply the heart itself with nourishment.

The **arch of the aorta** extends from the ascending aorta, above the root of the left lung, to the border of the fourth thoracic vertebra. During its course it gives off three branches, the *innominate*, the *left common carotid*, and the *left subclavian* arteries.

The **innominate artery** is a short arterial trunk 1½ to 2 inches in length arising from the right upper surface of the arch of the aorta and ascending obliquely toward the right sterno-clavicular articulation where it divides into the *right subclavian* and the *right common carotid* arteries.

The **left common carotid artery** arises at the middle of the upper surface of the aortic arch and the **right common carotid artery** is one of the terminal branches of the innominate artery. The common carotid arteries ascend obliquely on each side of the neck to the level of the laryngeal prominence where they divide into the *external* and the *internal carotid* arteries. The **external carotid** arteries supply the throat, tongue, face, ears, and the walls of the cranium; the **internal carotid** arteries supply the brain and the eyes.

The **subclavian arteries**, the right a terminal branch of the innominate artery and the left springing directly from the aortic arch, form the first part of the arterial trunks supplying the upper extremities. They give off branches to the back, the chest, the neck, and the brain, the principal one being the *vertebral* which runs upward through the transverse processes of the cervical vertebræ to the brain. Both pass upward and outward under the clavicle and over the first rib, at the outer border of which they continue as the **axillary arteries.** These vessels give off branches to the chest, the shoulder, and the arm. The axillary artery on passing the armpit becomes the **brachial artery**, which gives off branches to the bone and muscles of the arm, and terminates just below the level of the elbow by dividing into the *ulnar* and the *radial* arteries. The **ulnar artery**, the larger of the two branches of the brachial artery, extends along the medial side of the forearm to the palm of the hand where it forms the *superficial volar arch*. The **radial artery** extends along the outer side of the forearm to the palm of the hand where it forms the *deep volar arch*. The deep volar arch anastomoses with the superficial volar arch and supplies the hand with blood.

The **descending aorta** is from 7 to 8 inches long and extends from the arch of the aorta to the diaphragm. It gives off the following branches:

1. The **intercostal arteries** which are paired, 9 and 10 on each side, and supply the intercostal muscles and the adjacent structures.
2. The **superior phrenic** arteries, which are small branches supplying the upper surface of the diaphragm.
3. The **bronchial** arteries, two left and one right, which are the nutrient vessels of the lungs and the bronchi.
4. The **mediastinal** arteries which are numerous small branches supplying the lymph nodes and the areolar tissue of the mediastinum.
5. The **œsophageal** arteries, four or five in number, which anastomose around the œsophagus.
6. The **pericardial** arteries, three or four small vessels distributed to the pericardium.

The **abdominal aorta** begins at the aortic opening of the diaphragm at the lower level of the last thoracic vertebra, and terminates at the level of the fourth lumbar vertebra by dividing into the common iliac arteries. The branches of the abdominal aorta are divided into two groups, those which supply the viscera, the *visceral* arteries, and those which are distributed to the walls of the abdomen, the *parietal* arteries.

The visceral group consists of:

1. The **cœliac** artery, a short wide vessel, one-half inch in length which arises from the front of the aorta just below the diaphragm and divides into three branches; the **gastric**, supplying the stomach; the **hepatic**, supplying the liver, the gall bladder, and the duodenum; and the **splenic**, supplying the spleen and a part of the stomach and the pancreas.
2. The **suprarenal arteries**, right and left, which are distributed to the suprarenal glands.
3. The **renal arteries**, right and left, two large trunks arising from the sides of the aorta which supply the kidneys.
4. The **superior mesenteric** artery which arises from the front of the aorta just below the suprarenal arteries and supplies the small intestine, except the duodenum, and half of the large intestine.
5. The **spermatic** arteries (**ovarian** in female), right and left, which are distributed to the testes (ovaries in the female).
6. The **inferior mesenteric** artery which arises from the front of the aorta about an inch above its division and is distributed over the lower half of the large intestine and the rectum.

The parietal group includes:

1. The **inferior phrenic** arteries, right and left, which supply the lower surface of the diaphragm.
2. The **lumbar** arteries, usually four pairs, which supply the posterior and lateral abdominal wall and muscles.
3. The **middle sacral** artery, a small vessel which is a direct continuation of the abdominal aorta and supplies the sacrum and coccyx.

The **common iliac** arteries (left and right) begin at the division of the aorta, extend downward and outward for 2 inches, when they divide into the *hypogastric* and the *external iliac* arteries. The **hypogastric** arteries supply branches to the pelvic walls, the pelvic viscera, the external genitals, and the buttocks. The **external iliac** artery forms the first part of a continuous arterial trunk which supplies the lower extremity and extends to the lower border of the inguinal ligament, where it passes from the abdomen through the femoral opening and becomes the *femoral* artery. The external iliac artery partially supplies the anterior abdominal wall and the external genitals. The

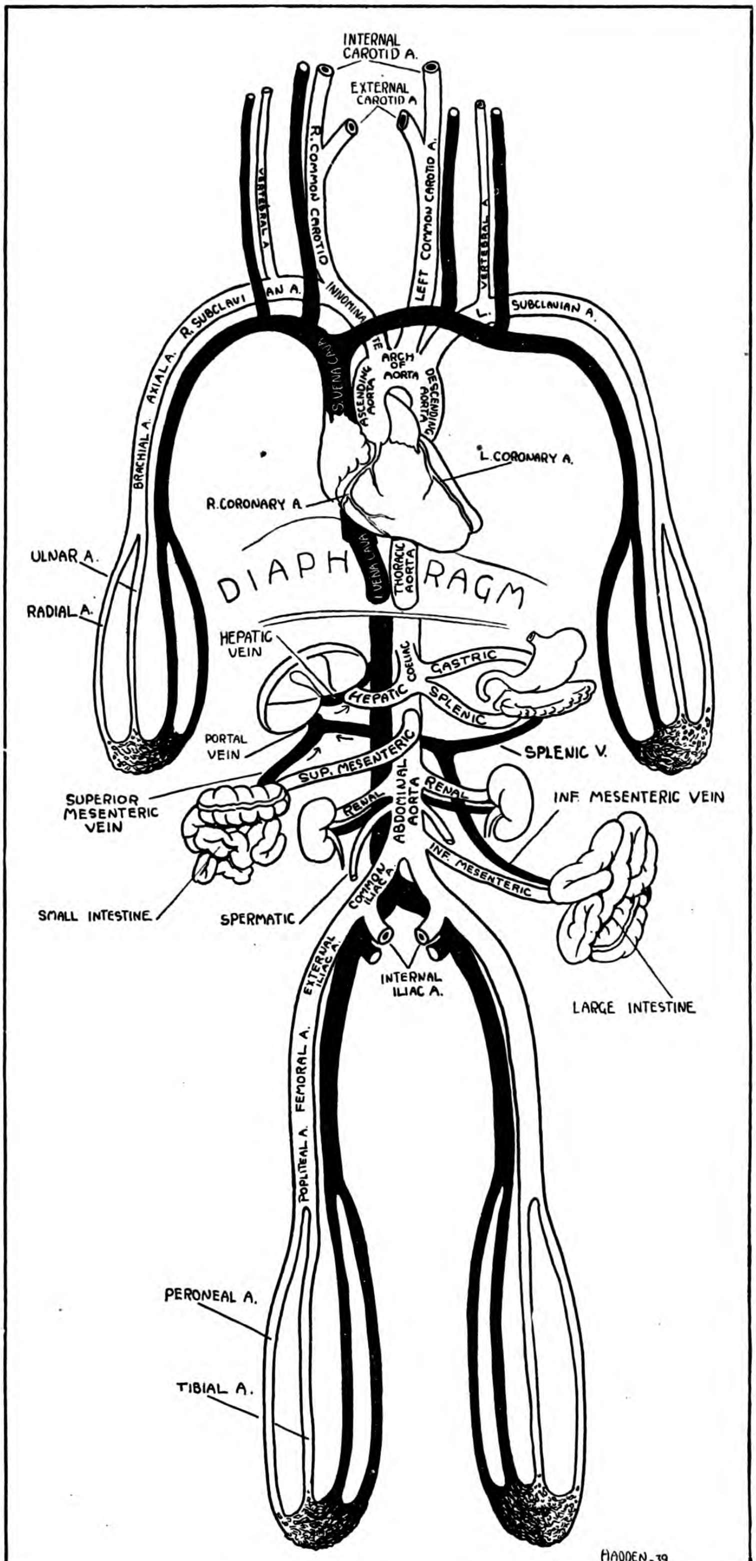

FIGURE 26.—Schema of principal arteries and veins. (U. S. Naval Medical School.)

femoral artery runs an oblique course along the femur inward and backward in the upper three fourths of the thigh to the posterior surface of the knee joint, where it becomes the *popliteal* artery. The femoral artery supplies branches to the muscles, the bone, and the skin of the thigh. The **popliteal** artery, after giving off branches anastomosing around the knee joint, divides into the *anterior* and the *posterior tibial* arteries. The **anterior tibial** artery, the smaller of the two branches, passes forward between the tibia and fibula, and then down the front of the leg to the ankle, where it becomes the *dorsalis pedis* artery which supplies the dorsal surface of the foot. The **posterior tibial** artery passes down the back of the leg to the ankle, where it divides into two branches which supply the sole of the foot. It gives off various branches, the largest of which, the *peroneal* artery, also passes to the plantar surface of the foot and supplies some of the muscles and skin of the foot and the ankle joint.

The **veins** begin as small branches called *venules* which unite to form larger vessels. Veins differ from arteries in that they have a larger capacity, thinner walls, and contain valves which assist in supporting the column of blood. This is necessary because most of the cardiac impulse is lost during the course of blood through the capillaries.

The veins are divided into the *pulmonary*, the *systemic*, and the *portal* systems.

It has been shown that the pulmonary arteries end in capillaries in the walls of the alveoli of the lungs. After oxygenation, blood is collected from these capillaries by the venules which unite to form a vein from each of the five lobes of the lungs. The right lung, however, sends but two veins to the heart as does the left lung, for the veins of the superior and the median lobes of the right lung unite. There are, then, four **pulmonary** veins carrying blood from the root of the lungs to the left auricle of the heart. These are the only veins in the body which carry arterial, or oxygenated blood.

The veins of the **systemic** circulation are arranged in two sets, the *deep* and the *superficial*. The **deep** veins as a rule accompany their corresponding arteries and usually are called by like names. The larger arteries have only one accompanying vein but the medium sized or smaller arteries usually have two accompanying veins which anastamose freely with each other. The **superficial** veins lie just under the skin where in many localities they may be easily seen, and end by entering the deeper tissues to join the deep veins.

The superficial veins of the head which drain the venous blood from the scalp and face and from the cancellous tissue of the skull empty into the right and left **external jugular** veins. The **anterior jugular** vein of the neck usually empties into the external jugular veins and with them drains the neck. The external jugular veins empty into the subclavian veins.

Venous blood from the brain and the interior of the skull drains into *venous channels* situated between two layers of the dura mater of the brain and having the same lining as the veins which empty into them. These channels are also known as *venous sinuses* and the most important ones are the **superior saggital sinus** running from front to back across the top of the brain, the two **transverse or lateral sinuses,** one on each side of the brain, and the two **cavernous sinuses,** one on each side of the sphenoid bone. The cavernous sinuses communicate with the veins of the face through the veins of the orbits and are therefore especially receptive to the backward spread of infective organisms from the nose and cheeks with resultant clotting of blood in the sinuses and almost certain death. The saggital and cavernous sinuses empty into the transverse sinuses and they empty into the **internal jugular** veins, one on each side of the

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neck, which, with their tributaries, also drain the deep portions of the neck, the tongue, the pharynx, and the thyroid gland.

The superficial veins of the upper extremity start from the *dorsal venous arch* and the *volar venous plexus* of the hand and consist of the *cephalic, basilic, median,* and tributary veins. The **cephalic** vein passes up the outer side of the forearm and arm in front of the elbow and empties into the upper part of the axillary vein just below the clavicle. Below the elbow it gives off the *median cubital* or *median basilic* vein which passes across and joins the basilic vein. The **basilic** vein passes up the inner side and back of the forearm, receives the median cubital vein below the elbow, then passes upward in the arm and in the axilla joins the brachial veins to form the axillary vein. The **median** vein passes up the forearm to the level of the elbow where it joins the basilic vein.

The deep veins of the upper extremity begin from smaller veins in the hand as the **radial** veins and the **ulnar** veins and as they pass upward receive tributary veins. In front of the elbow they unite to form the **brachial** veins which continue upward through the arm and in the axilla unite with the basilic vein to form the axillary vein. The **axillary** vein passes on across the axilla and at the outer border of the first rib becomes the **subclavian** vein which continues on to the sternal end of the clavicle and there unites with the internal jugular vein to form the innominate vein. At this point the right subclavian vein receives the lymphatic duct and the left receives the thoracic duct. Before uniting with the internal jugular vein the subclavian vein receives the external jugular vein and sometimes the anterior jugular vein.

The **innominate** veins, one on each side, receive numerous tributary veins draining various parts of the thorax and pass obliquely downward toward the sternum and unite to form the *superior vena cava* which receives the **azygos** vein draining most of the intercostal spaces and several small tributary veins. The **superior vena cava,** which returns to the heart all venous blood from the body above the diaphragm, descends on the right side of the center of the thorax, with a slight convexity to the right, and ends in the upper part of the right auricle of the heart.

The blood which has supplied the heart itself with nourishment is returned as venous blood by a *venous channel* called the **coronary sinus** which lies in a groove on the back of the heart and enters the right auricle near the junction of the inferior vena cava with the right auricle. Tributary veins, most of which empty into the coronary sinus, collect the venous blood from the heart.

The superficial veins of the lower extremity are the **internal, great,** or **long saphenous** vein which starts on top of the inner side of the foot and runs up the inner side of the leg and thigh to terminate just below the groin in the femoral vein, and the **external, small,** or **short saphenous** vein which starts in a similar manner on the outer side of the foot and terminates just behind the knee in the popliteal vein. Both saphenous veins are joined by numerous tributary veins. The principal deep veins of the lower extremity are the *anterior* and *posterior tibial* veins, the *peroneal* veins, the *popliteal* vein, the *femoral* vein, and the *deep femoral* vein. The **anterior** and **posterior tibial** veins start from smaller veins in the foot, run upward and unite behind the knee to form the popliteal, the posterior tibial veins in the passage upward being joined by the **peroneal** veins which accompany the peroneal artery. The **popliteal** vein extends upward through the lower third of the thigh where it becomes the femoral vein, being joined shortly after its origin by the small saphenous vein. The **femoral** vein extends upward through the upper two-thirds of the thigh and then becomes the external iliac vein, being joined just before its termina-

tion by the great saphenous vein. The **deep femoral** vein communicates with the popliteal vein below and the inferior gluteal vein above.

Only the principal veins of the abdomen and pelvis will be named, beginning with the **external iliac** vein which runs along the brim of the pelvis to the sacro-iliac joint where it unites with the **hypogastric** or **internal iliac** vein, which drains the pelvis, to form the common iliac vein. The **common iliac** veins, one from each side of the body, pass obliquely upward and unite on the right side of the fifth lumbar vertebra to form the *inferior vena cava*, into which the **lumbar** veins, the **renal** veins with the left **suprarenal** and left **spermatic** or **ovarian** veins, the right **suprarenal** and right **spermatic** or **ovarian** veins, and the **hepatic** veins empty. The **inferior vena cava**, which returns to the heart all venous blood from the body below the diaphragm, ascends along the spinal column on the right of the aorta, passes through the diaphragm into the thoracic cavity and ends in the lower part of the right auricle of the heart.

The **portal system** of veins consists of the veins which drain blood from the stomach, the intestines (with the exception of the lower part of the rectum), the spleen, the pancreas, and the gall-bladder. Among the veins collecting blood from these viscera are the **splenic** and the **superior mesenteric** veins which unite behind the neck of the pancreas to form the *portal* vein, the principal one in the system as all the others ultimately empty into it. The veins communicating with the portal vein all have numerous tributary veins. The **portal** vein runs upward and slightly to the right to the transverse fissure of the liver where it divides into two branches which enter the right and left lobes of the liver respectively. After entering the liver the branches of the portal vein continue to branch until they end in small capillaries in blood spaces in the liver substance where the *hepatic* veins begin and, after leaving the liver, continue on to enter the inferior vena cava, as mentioned before. The purpose of the portal circulation is to subject the blood containing the end products of digestion to the special action of the liver prior to entering the general circulation.

THE LYMPH AND THE LYMPH-VASCULAR SYSTEM

Lymph is a colorless fluid, rich in white blood cells, of essentially the same composition as blood plasma, and largely the product of the filtration of blood plasma through the walls of the blood capillaries. It is found in the lymph vessels and in all of the tissue spaces of the body and serves as a medium for carrying nourishment and oxygen to the tissues and waste products from them. The tissues and organs of the body are bathed in lymph which then acts as a lubricant in aiding movement. After a meal, the lymph coming from the small intestine has a milky appearance because of the presence of fat in it and it is then called *chyle*.

The lymph-vascular system.

Lymph vessels and lymph glands constitute the lymph-vascular system which forms a network throughout the body and connects with serous and tissue spaces. There are also certain lymph trunks in the system the most important of which is known as the *thoracic duct*. The flow of lymph in the system is always from the tissues toward the terminal lymph vessels and is maintained in this direction mainly by the difference in pressure at the two ends of the system. The pressure is lowest at the terminal end and the terminal lymph vessels are the thoracic duct and the *right lymphatic duct* which empty into the left and right subclavian veins, respectively.

The lymph vessels.

In many respects the lymph vessels resemble veins and have been found in every part of the body which possesses blood vessels except the brain, spinal cord, eyeball, and internal ear. Like the veins many of the lymph vessels contain valves which prevent the backward flow of the lymph, but, unlike the veins, they communicate directly or indirectly with the great serous cavities of the body and their continuity is interrupted by interposed lymph glands. Lymph vessels find their beginning in the tissues and organs of the body where they are known as *lymphatic capillaries* and which unite to form larger vessels. As the lymph vessels attain a larger size their walls become stronger due to the presence of elastic tissue and the larger vessels are composed of three layers as are blood vessels. Lymph vessels are known as *superficial lymph vessels* and *deep lymph vessels*, according to their position in the body. The superficial vessels collect lymph from the skin and subcutaneous tissue; the deep from all other parts of the body.

The **thoracic duct** is about the size of a goose quill and is from 15 to 18 inches long. It extends from the level of the second lumbar vertebra to the root of the neck where it empties into the left subclavian vein at its junction with the left internal jugular vein. This lymph vessel lies just in front of the spinal column and receives the lymph from all lymphatic vessels of the body except those from the right side of the head, the right upper extremity, the right chest and its contents, the right side of the diaphragm, and the upper surface of the liver, all of which finally empty into the *right lymphatic duct*.

The **right lymphatic duct**, which is not always present in the body as a distinct lymph trunk, is about ½ to ¾ inch long, lies at the right side of the root of the neck, and empties into the right subclavian vein at its junction with the right internal jugular vein.

The lymph glands.

These are small bean-shaped bodies that occur in groups of from 2 to 15 along the courses of the lymph vessels except for a few in the subcutaneous tissue that are single. These groups of lymph glands are known as *lymph nodes*. The glands vary considerably in size, are composed of lymphoid tissue, and act partly as filters for the removal of minute infective organisms and particles from the lymph stream. They also are the source of origin of most of the white blood cells known as lymphocytes.

THE RESPIRATORY SYSTEM AND RESPIRATION

Respiration, or breathing, in some form is a characteristic of all living organisms and without it life cannot continue. It may be defined as the process of gaseous exchange between a living organism and the medium in which it lives. The medium in which the animals and plants of Earth live is air, the mixture of gases which surrounds the earth. One of the gases in air is oxygen which both animals and plants require for their vital processes, those functions of the body on which life is directly dependent. These vital processes, for which the term *metabolism* is used, are the chemical changes proceeding continually in living cells by which the energy to maintain the processes and activities necessary for life is provided. In the production of this energy, destruction or waste occurs and one of the waste products is the gas called carbon dioxide which is exchanged for oxygen in the process of respiration. In the single-celled animals and plants the exchange takes place directly between the organism and its surrounding medium but in the more complex animals some form of respiratory apparatus is necessary. Man and the air-breathing

vertebrates are provided with lungs or gills where the waste product carbon dioxide is exchanged for oxygen present in the surrounding medium of air.

The respiratory apparatus.

In man the respiratory apparatus consists essentially of the *lungs* and the air passages leading into them (fig. 27), the *nasal chambers*, the *mouth*, the *pharynx*, the *larynx*, the *trachea*, and the *bronchi*. The *thorax*, the *ribs*, and the *diaphragm* and other respiratory muscles taking part in respiratory movements may be considered as accessory respiratory apparatus.

The **nasal chambers** are the normal entrance for air to the respiratory tract. They are irregular, wedge-shaped cavities having a vestibule, a respiratory region and an olfactory region and are covered with a highly vascular mucous membrane which in the respiratory region serves to warm and moisten the inspired air. In the respiratory region there are many fine hairs called *cilia* which act as filters and remove dust particles from the air being inhaled. The *nasal septum* separates the two chambers, both of which open posteriorly into the pharynx.

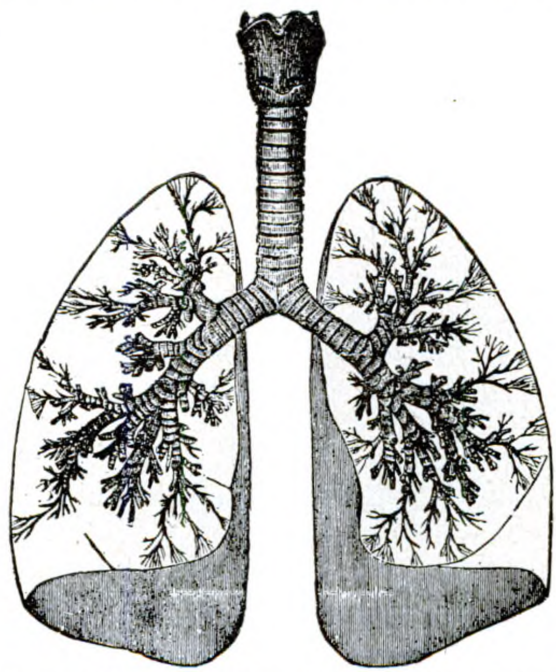

FIGURE 27.—The larynx, trachea, right and left bronchi, and the lungs. The latter have been cut open to show the method of division and subdivision of the bronchi. (Mason.)

The **mouth**, strictly speaking, is a part of the alimentary canal or digestive tube, but because the back of it connects with the pharynx and respiration can therefore be carried on through it when it is open, the mouth is sometimes considered as a part of the respiratory apparatus.

The **pharynx**, like the mouth, is really a part of the alimentary canal, of which it is the expanded upper part. In the respiratory system it serves merely as a passageway for the air as it connects above with the nasal chambers and below with the larynx.

The **larynx**, or *organ of voice*, lies in the upper and front part of the neck between the trachea and the hyoid bone and tongue. Above it opens into the pharynx, below it becomes continuous with the trachea. It is a triangular, box-like structure made up of several cartilages connected together at certain points by ligaments and membranes, and the upper part of the largest of these cartilages, the *thyroid cartilage*, forms a marked prominence in the midline of the neck which is the so-called "Adam's apple." In the upper part of the larynx there is a space commonly called the *glottis*. Along the sides of this space, extending from front to back and projecting into it are two pairs of elevated folds of mucous membrane. The folds in the upper pair are called the *false vocal cords;* those of the lower, more definite pair are the *true vocal cords*, the chief agents in the production of voice. Extending upward and

backward over the upper opening of the larynx is a thin leaf-like flap of fibrous-cartilage called the *epiglottis* which in the act of swallowing directs the material being swallowed into the opening of the œsophagus.

The **trachea**, or *windpipe*, is a wide fibro-muscular tube which extends downward from the larynx about 4 to 4½ inches and there divides into the right and left bronchi. It lies in front of the œsophagus and its walls consist of fibro-elastic membrane and muscular tissue with a lining of mucous membrane. Because of the elasticity of its walls the trachea has considerable mobility but to prevent dragging on the roots of the lungs during movements of the head and neck the lower end is fixed in its position. Embedded in the fibro-elastic membrane of the trachea is a series of from 15 to 20 C-shaped cartilaginous bars which strengthen the tube and keep it always open. These bars are complete in front but incomplete behind and consequently the back wall of the trachea is flattened. In the mucous membrane lining of the trachea are many cilia which help to produce an upward movement of the mucus present on the surface of the mucous membrane.

The **bronchi** begin as the two terminal branches of the trachea and are known individually as the right and the left *bronchus*. They are structures similar to the trachea but have cartilaginous plaques instead of bars and each bronchus enters into the corresponding lung. There they branch and rebranch like a tree, and the smallest branches, the *bronchioles*, end in tiny membranous sacs called air vesicles or *alveoli*, which are multitudinous in number and make up the greater part of the lung substance. The alveoli have very thin walls in and about which the blood capillaries are distributed in such numbers that they form the densest plexus, or network, of capillaries to be found anywhere in the body. The right bronchus is larger, shorter, and more vertical than the left and foreign bodies in the trachea are likely to be directed toward it.

The **lungs**, two in number, occupy practically all of the cavity of the thorax, one being located in each of the two chambers called pleural cavities into which the thoracic cavity is divided by the *mediastinal septum*. They are light, soft spongy organs made up of the alveoli, bronchial tubes, blood vessels, lymphatics, and nerves, held together by connective tissue. The right lung has three lobes and is larger, broader, and shorter than the left which has only two lobes. The surfaces of the lungs next to the ribs are convex so as to fit the curvature of the thorax, and the other surfaces present concave hollows to fit the various organs which are in contact with the lungs. One of these hollows is the pericardial concavity which is adapted to the shape of the heart. Above the back of this hollow there is a wedge-shaped depression on each lung known as the *hilum*, within which the bronchus, blood vessels, nerves, and lymph vessels enter and leave. These structures are bound together by a sheath of pleura to form a pedicle or stem by which the lung is attached to the mediastinal wall of the pleural cavity. This pedicle or stem is called the *root* of the lung. There are two types of circulation in the lungs, the pulmonary, which brings the blood from the right heart to the lungs for the exchange of gases called oxygenation or aëration and returns it to the left heart, and that from the bronchial branches of the aorta which supply the lung tissue itself. The nerve supply of the lungs is from the vagus nerve and the sympathetic nervous system.

The **pleura** is a serous membrane which envelopes the lungs and lines the walls of the thoracic cavity. It is without a break in its continuity and thereby forms a closed sac within which are all the organs located in the thorax. The inner surface of the pleura has a smooth, glossy appearance and is moistened with a small amount of serous fluid. The portion of the pleura which covers

the lungs is known as *pulmonary* or *visceral pleura* and is very firmly bound down to the surface of the lung. It is very thin and completely covers the entire surface of the lung. At the root of the lung the pulmonary pleura turns back on itself to line the walls of the thoracic cavity and it is then known as the *parietal pleura* or, according to the different parts of the thoracic cavity it lines, as the *costal pleura*, the *diaphragmatic pleura*, the *mediastinal pleura*, and the *cervical pleura*. Each lung is enveloped in its own pleural sac and these sacs do not communicate with each other. The serous fluid on the pleura permits respiratory movements of the lungs with little if any friction as it acts as a lubricant. The inner surface of the pleura sometimes becomes roughened by inflammation and this condition is known as pleurisy. Should the thoracic wall be perforated, thus allowing air to enter a pleural cavity, the lung of that side will collapse.

The process of respiration.

As has been explained at the beginning of this section, respiration is a necessity in the life of air-breathing vertebrates and it may be said that the purpose of respiration is to supply the body with oxygen and to remove carbon dioxide. This interchange of gases, which takes place in the lungs, is known as the oxygenation or aëration of the blood, and the actual exchange occurs in the alveoli of the lungs. Oxygen and carbon dioxide readily pass through the thin membranous walls of the aveoli and of the capillaries because both have the property of being able to pass through permeable and semi-permeable membranes in accordance with the natural laws of diffusion of gases.

The gaseous exchange or absorption of oxygen and elimination of carbon dioxide that takes place in the lungs between the blood in the capillaries in the walls of the alveoli and the air in the alveoli may be called *external respiration;* the similar exchange that occurs in the systemic capillaries between the blood and the tissues of the body may be called *internal* or *tissue respiration*. The latter is the respiration truly vital to life.

In the section concerning blood it was stated that the blood carries oxygen from the lungs to the body tissues and carbon dioxide from the tissues to the lungs. The oxygen required by the tissues for their activities is carried to them principally in *chemical combination* with the hæmoglobin in the red blood cells, only a very small amount being carried in *physical solution* as oxygen is not a very soluble gas. In the compound formed by the chemical combination of hæmoglobin and oxygen, called oxyhæmoglobin, the hæmoglobin is almost completely saturated with oxygen.

The carbon dioxide produced in the tissues during their metabolic activity is removed from them in *chemical combination* with hæmoglobin and with constituents in the plasma, and in *physical solution* in the plasma. Carbon dioxide is a very soluble gas and upon reaching the plasma some of it dissolves to form *carbonic acid* which reacts with sodium chloride in the plasma and produces *sodium bicarbonate*, and a small amount is retained in the plasma in simple physical solution. The remaining carbon dioxide enters into chemical combination with hæmoglobin to form carb-hæmoglobin.

Oxygenated blood reaches the tissues through the blood capillaries at which point the oxygen content, and consequently its pressure, is higher than in the tissues. This difference in oxygen pressure causes the oxyhæmoglobin, which under those conditions has the property of dissociation, to give off free oxygen which diffuses through the thin walls of the capillaries and the lymph into the tissue cells.

The blood, having given up its oxygen to the tissues, again contains uncombined or *reduced hæmoglobin*, and therefore is ready to take up carbon dioxide,

Being under higher pressure in the tissues than in the blood, the carbon dioxide diffuses from the tissue cells through the lymph and the capillary walls into the blood where it is taken up as previously explained.

Deoxygenated or impure blood is carried to the lungs where the oxygen pressure in the alveoli is higher and the carbon-dioxide pressure lower than in the blood. In the lungs the carbon dioxide which was changed into sodium bicarbonate changes back to carbon dioxide. On reaching the capillaries in the alveoli the lower pressure of the carbon dioxide there causes that in the blood to diffuse through the thin walls of the capillaries and of the alveoli until an equilibrium in pressure between the carbon dioxide in the blood and in the alveoli is reached. At the same time the higher pressure of oxygen in the alveoli causes it to diffuse through the walls of the alveoli and the capillaries and enter the blood where it combines with the reduced hæmoglobin and oxyhæmoglobin is again present in the blood. In the lungs the blood does not ordinarily give up all its carbon dioxide as some is required for its action in the maintenance of respiration.

The chemical change attendant upon the formation of sodium bicarbonate from carbon dioxide plays an important part in maintaining the slightly alkaline reaction of the blood.

The ordinarily automatic, rhythmical movements of respiration are controlled by the *respiratory center* in the medulla oblongata which originates the impulses causing them. These impulses pass down the spinal cord to the nerves which supply the respiratory muscles. Probably the most important of these nerves is the *phrenic* which supplies the diaphragm, others being the *vagus*, supplying the larynx, and the *intercostals*, supplying the muscles of the thorax and abdomen.

The respiratory center may be affected by various conditions and it follows that the respiration is also affected. An increase in the amount of carbon dioxide (which has acid properties) in the blood increases the acidity of the blood and is immediately followed by increased respiratory movements. A decrease in the amount of carbon dioxide in the blood can cause all respirations to cease, which condition will remain until the normal amount of carbon dioxide is again present in the blood which stimulates the respiratory center and breathing is resumed. External sensations may affect the respiratory center; for example, the splashing of cold water on the face and chest often will stimulate resumption of breathing; a sudden plunge into cold water will cause a deep, gasping respiration. Emotional disturbances affecting the higher centers of the brain may alter respiration; for example, in excitement the respirations may increase while in shock they are usually shallow and sighing; laughing, crying, speaking, or singing, may to some extent modify respiratory movements. If for any reason the respiratory center loses its blood supply failure of respiration will ultimately occur.

As has been stated in the section concerning muscles, the respiratory muscles ordinarily act automatically without conscious effort of the will. Activity of those muscles produces alternate inspirations and expirations of air in and out of the lungs which, with a period of rest between movements, constitutes what is called the *cycle of respiration*. This cycle is divided into three phases: 1. *Inspiration*, or the flow of air into the lungs; 2. *Expiration*, or the flow of air out of the lungs; and 3. A period of *rest*.

The cycle is completed about 14 to 18 times per minute in the normal adult while at rest. In the act of inspiration the diaphragm contracts and the ribs are elevated by the accessory muscles of respiration, thus enlarging the thoracic cavity and creating a negative pressure in the cavity. This permits the lungs to expand and causes the outside air to rush in and equalize the pressure. In

expiration the diaphragm relaxes, and the elasticity of the lungs, together with the weight and the elasticity of the chest walls, causes the chest to return to its original size, expelling a certain amount of air from the lungs.

The lungs, when filled to their utmost capacity, hold about 4,500 cc of air. Practically 500 cc of air is breathed out at a normal quiet expiration. This air which is changed at each respiration is called the *tidal air*. The amount of air breathed out or in may be increased by forceful expiration and inspiration. The amount of air left in the lungs after the most forceful expiration is about 1,000 cc and is known as the *residual air*. Under normal conditions the reserve supply of air in the lungs is about 2,600 cc.

Certain sounds are produced by the entry and exit of air from the alveoli of the lungs and the bronchi. These sounds may be variously modified in lung diseases.

Certain abnormal types of breathing may be noted. *Dyspnœa* is labored or difficult breathing. *Apnœa* is a condition in which there is a temporary cessation of breathing. *Asphyxia* is the condition produced by oxygen starvation and is caused by prolonged interference with the aëration of the blood.

THE DIGESTIVE SYSTEM AND DIGESTION

In order to understand the processes concerned with digestion, it is necessary to know the meaning of the various terms used in describing this process.

Digestion is the process or act by which various food substances are converted into simpler substances which can be absorbed and assimilated.

Mastication is the division of food into small particles. This is accomplished by means of the teeth.

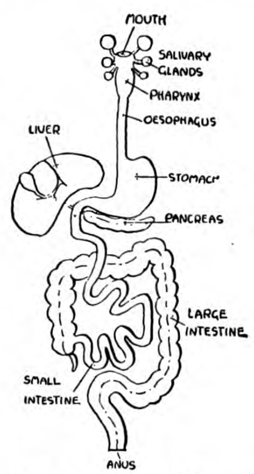

FIGURE 28.—Diagram of the alimentary tube and its appendages. (Testut.)

Insalivation is the mixing of food with the saliva. This takes place within the mouth.

Deglutition or swallowing is the act of transferring food from the mouth to the stomach.

Enzymes are complex organic substances capable of effecting, by catalytic action, the transformation of some other compound or compounds.

Absorption, as applied to digestion, means the taking up of digested food products, either in solution or suspension, by the blood and the lymph from the alimentary tract.

Peristalsis is a wave-like contraction which passes along the intestinal tract. This movement moves or propels the contents of the intestine.

Defæcation is the term applied to the act of expelling fæces from the rectum.

The digestive system consists of the *alimentary canal* and the *accessory organs* (fig. 28). The **alimentary canal** is a continuous tube extending from the mouth to the anus, 28 to 30 feet long and varying in size. It is composed of the *mouth*, the *pharynx*, the *œsophagus*, the *stomach*, and the *small* and *large intestine*. The **accessory** organs of digestion are the *teeth*, the *tongue*, the *salivary glands*, the *liver*, the *gall bladder*, and the *pancreas*.

The mouth or *buccal cavity* is nearly oval in shape, and is formed in front by the lips; above, by the *hard palate* in front and the *soft palate* behind; at the sides, by the *cheeks;* and below or at the floor, by the *tongue*. This cavity opens posteriorly into the *pharynx* from which it is partially separated by the

uvula, a small flap of mucous membrane hanging from the soft palate, and the *anterior pillars of the fauces*, two curved folds of mucous membrane running from the uvula to the sides of the base of the tongue. In the small depression between the anterior and the posterior pillars of the fauces, on either side, is a small mass of lymphoid tissue called the *tonsil*. The semicircular borders of the upper and lower jaw bones, the *alveolar processes*, contain sockets for the reception of the *teeth*, of which there are two sets, the *deciduous*, or "*milk*" *teeth*, which erupt between the ages of 6 months and 3 years and are 20 in number, and the *permanent teeth*, which replace the first set between the ages of 6 and 21 years. In the adult there are 32 teeth, 16 in each jaw, 4 incisors, 2 cuspids (canines), 4 bicuspids, and 6 molars. The structure of the teeth is described in the section on Emergency Dental Treatment (p. 165).

The **tongue** is a muscular organ occupying the floor of the mouth. It is covered with mucous membrane, contains the special organs of taste, is an important organ of speech, and assists in the mixing and swallowing of food.

The salivary glands, consisting of three pairs, are compound glands which discharge their secretion, *saliva*, into the mouth. The *parotid glands* situated in front of and below the ears, discharge their secretion by way of *Stenson's ducts* which enter the mouth opposite the second upper molar teeth. The *submaxillary* glands, lying under the lower jaw, and the *sublingual* glands, lying under the tongue, discharge their secretion by way of ducts opening into the floor of the mouth and known as *Wharton's ducts.*

The pharynx is the expanded upper part of the alimentary canal and lies behind and communicates directly with the mouth, the nasal chambers, and the larynx. By means of the *Eustachian* or *auditory tubes* it also communicates with the tympanic cavities, or the middle ears. That part of the pharynx which is above the level of the soft palate is used only for respiration, the other part is used for the passage of food. It is a fibro-muscular structure and extends from the base of the skull, above, to the level of the sixth cervical vertebra below, where it joins and is continuous with the œsophagus. It is somewhat funnel-shaped with the wide part at the top. The upper part is open in front but the lower part gradually becomes tube-like, the anterior and posterior walls finally join, and the opening reduces in size until it is only a slit except during the passage of food.

The **œsophagus**, or *gullet*, is a muscular tube about 10 inches long extending from the pharynx, above, to the stomach, below. It is situated practically in the median line of the body and inclines slightly to the left. Its upper part lies directly behind the trachea and in front of the vertebral column, the remainder in front of the vertebral column. It passes downward through the thoracic cavity and pierces the diaphragm about one-half inch above its termination at the cardiac orifice of the stomach. Its walls are composed of three layers, an inner lining of mucous membrane, a middle layer of connective tissue, and an outer coat of both voluntary and involuntary muscle tissue. In addition it is surrounded by a covering of connective tissue which permits its free movement and by which it is loosely connected to the various structures adjacent to it.

The remaining parts of the digestive system are located in the abdomen which will be briefly described before continuing with the digestive system.

The **abdomen** is that portion of the trunk lying below the diaphragm and consists of a wall made up in part of bones, muscles, tendons, etc., and of the largest cavity in the body in which are contained the stomach, liver, gall bladder, intestine, pancreas, spleen, kidneys, bladder, some of the generative organs, blood vessels, nerves, etc. This cavity is termed the *abdominal cavity* but for

descriptive purposes is considered in two parts, an upper, larger part called the *abdomen proper*, and a lower, smaller part called the *pelvis*. The abdominal cavity in the adult male is shaped much like a barrel, with the upper end bounded by the diaphragm and somewhat wider than the lower. For convenience in describing or locating the organs contained in the abdominal cavity the abdomen is considered as divided into nine regions by imaginary lines drawn on its ventral surface and each region is named appropriately (fig. 29). A continuous, smooth membrane known as the *peritoneum* covers the wall of the abdominal cavity and the surfaces of the organs in it.

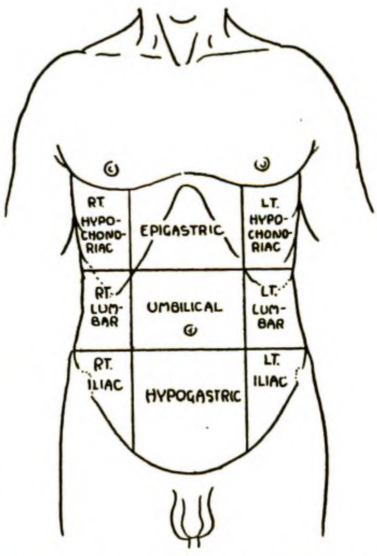

FIGURE 29.—Surface markings of thorax and abdomen. (Gray, modified.)

The **peritoneum** is a thin, glistening, serous membrane composed of a layer of fibrous tissue covered over on the cavity side with a layer of flattened endothelium which secretes a small quantity of serous fluid known as *peritoneal fluid* that lubricates the inner surface of the peritoneum and permits movement of the structures in the cavity with the least degree of friction. In the male the peritoneum is a completely closed sac but in the female it is indirectly open to the surface. The portion of the peritoneum lining the walls of the abdominal cavity is known as the *parietal peritoneum*; that which clothes the organs, or viscera, therein is known as the *visceral peritoneum*. Parts of the duodenum, the colon, the bladder, and the kidneys are not covered with peritoneum; the remaining principal abdominal organs are completely clothed with it. Numerous folds of the peritoneum extend between the various organs and serve to connect them with the posterior wall of the abdomen and with one another, such as the various ligaments of the liver, and the *mesentery* which holds the intestine in place and contains the vessels which supply it. The *omentum*, an apron-like structure composed of four layers of peritoneum with enclosed fat, is pendant from the transverse colon and is freely movable. It is of service in walling off inflammations or infections within the abdominal cavity.

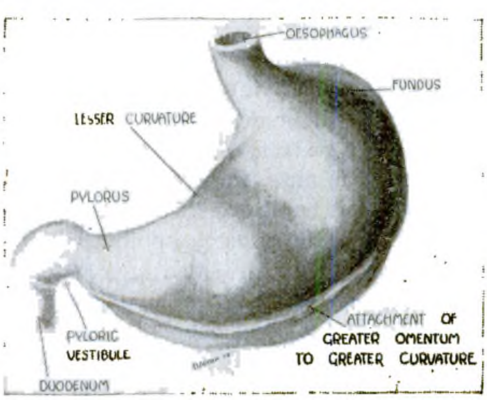

FIGURE 30.—The stomach. (Cunningham modified.

The **stomach** is a hollow, muscular organ situated in the abdomen between the œsophagus, above, and the small intestine, below (fig. 30). In shape it is much like a gourd, its wide, upper end, which is called the *fundus*, lying in the hollow of the diaphragm and directed upward, backward, and to the left, and its narrow, tapering end passing downward, forward, and to the right. The fully distended stomach of an adult is about 10 to 11 inches long, its greatest diameter is about 4 to 4½ inches, and its

average capacity is about 2 to 2½ pints. The size and shape of the stomach depend considerably upon its contents. The stomach has two openings, one at the upper, œsophageal end called the *cardiac orifice*, and one at the lower, intestinal end called the *pylorus* or *pyloric orifice*. The portion of the stomach about the cardiac orifice is called the *cardiac part*, that about the pyloric orifice the *pyloric part*. The portion of the stomach which extends from the fundus to the pyloric part, called the *body of the stomach*, forms a rounded chamber, is capable of great distension, and contracts to a narrow, tube-like structure when the stomach is empty. Surrounding the pylorus is a circular ring of muscle called the *sphincter pylori* which closes and opens the stomach outlet. The upper surface of the stomach is concave and is known as the *lesser curvature;* the lower surface is convex and is known as the *greater curvature*. The walls of the stomach consist of four layers of tissue, a thick, inner lining of mucous membrane, a layer of strong connective tissue closely attached to the lining and loosely to the muscular layer, a layer of muscular tissue in which the fibers are arranged circularly, obliquely, and longitudinally in sets, and an outer coat of serous membrane which is formed of the peritoneum. When the stomach is empty the three outer coats contract and the inner coat is thrown into many folds which disappear when the stomach is distended. In the inner lining are numerous glands which secrete the gastric juice.

The **intestine** is a musculo-membranous tube about 28 feet long beginning at the pyloric orifice of the stomach and ending at the *anal orifice* which opens on the surface. It consists of the *small* and the *large intestine* which together occupy a large portion of the abdominal and pelvic cavities. The **small intestine** is about 23 feet long and is divided into three parts, the first, the *duodenum*, immediately succeeds the stomach and is about 1 foot long; the second, the *jejunum*, is about 9 feet long; and the third, the *ileum*, is about 13 feet long. The duodenum lies in a horseshoe-shaped curve and is closely fixed to the posterior abdominal wall; the jejunum and the ileum lie in a series of irregular loops which are quite freely movable. The small intestine is made up of four layers of tissue, an inner lining of mucous membrane, a layer of loose but strong connective tissue attached to the lining and the muscular layer, a layer of muscle tissue consisting of an inner stratum of involuntary muscle fibers arranged circularly and an outer stratum of involuntary muscle fibers arranged longitudinally, and an outer coat of serous membrane which is formed of the peritoneum. The mucous membrane lining of the small intestine lies in folds, some of which disappear when the intestine is distended while others are permanent, and when examined it presents a soft, velvety appearance because of the presence on it of an enormous number of minute, fingerlike projections called *villi* (fig. 31). The villi contain small blood capillaries and lymph vessels, called *lacteals*, and play an important part in the process of digestion by collecting digested food products. In the mucous lining are also many simple glands which secrete a digestive fluid, the *intestinal juice*. The small intestine opens into the large intestine through the *ileocæcal orifice* at the junction of the cæcum with the ascending colon. This opening is guarded by a valve called the *ileocæcal valve* which prevents the regurgitation of contents of the large into the small intestine. The valve consists of two cresent-shaped segments or folds that project into the cæcum and are continuations of the walls of the ileum. The muscle fibers in these segments keep the opening which lies between them closed except during the passage of digested food from the small into the large intestine.

The **large intestine** begins on the right side about 2½ inches below the ileocæcal junction and extends to the anus. It is about 5 feet long, is larger in diameter than the small intestine, and is divided into the following parts:

the cæcum; the ascending colon, which curves at the lower border of the liver to form the *hepatic flexure;* the *transverse colon* which crosses the abdomen from right to left to the splenic region where it curves downward, forming the *splenic flexure;* the *descending colon*, which descends to the brim of the pelvis over which it curves to form the *sigmoid flexure;* and the *rectum*, the terminal dilated portion of the intestine that communicates with the outside through the *anal orifice*. The walls of the large intestine are arranged in the same manner as those of the small intestine, and are of the same structure, except that the longitudinal muscle fibers of the large intestine are arranged in three

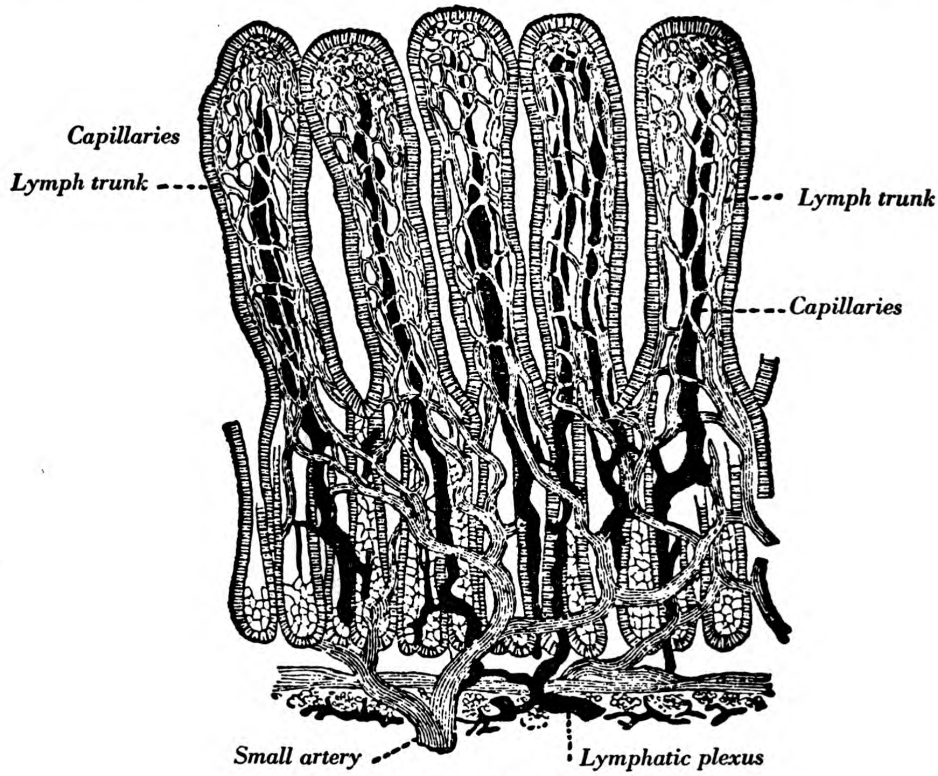

FIGURE 31.—Villi of small intestine. (Cadiat.)

bands which extend the entire length of the colon and are a little shorter than the colon, thus causing the walls to pucker. The mucous lining of the large intestine is smooth and contains no villi, but secretes a mucus which lubricates the tube. At the blind end of the cæcum is a small worm-like projection called the *vermiform appendix* which is the seat of the pathological condition known as appendicitis.

This concludes the description of the structures and organs comprising the alimentary canal and the accessory organs of digestion which have not been discussed will now be considered.

The liver is the largest gland in the body and weighs from 50 to 60 ounces in the normal adult (fig. 32). This organ measures 8 to 9 inches from side to side, 4 to 5 inches perpendicularly, and 6 to 7 inches from front to back, is located in the very upper part of the abdomen, directly beneath the diaphragm, more of it lying to the right side than to the left, and is held in position by ligaments which are formed by the peritoneum. Its general shape is that of

a wedge, much thicker at the right than at the left, and with the thin edge turned forward. The upper surface of the liver is convex, conforming to the dome shape of the diaphragm. The lower surface is irregular and contains many fissures and fossæ.

The liver is divided into five lobes by five fissures, the largest of which is the *transverse fissure*, through which the vessels, ducts, and nerves enter and leave the organ. The liver has a double blood supply, one being from the hepatic artery of the systemic circulation, and the other from the portal vein carrying absorbed food material from the intestine. The drainage for both sets of capillaries is the hepatic vein which empties into the inferior vena cava. The liver is made up of many minute lobules of liver cells arranged concentrically about a central vein, which is a small venule of the hepatic vein. The lobules are held together by connective tissue which contains the capillaries of the hepatic artery and the portal vein, as well as the bile ducts, and the blood from these vessels comes in close association with the liver cells in order to reach the central venule. In the *gall-bladder fissure* on the lower surface of the liver is the *gall-bladder*, a small, muscular, pear-shaped sac about 3 to 4 inches long which serves as a reservoir for the *bile*.

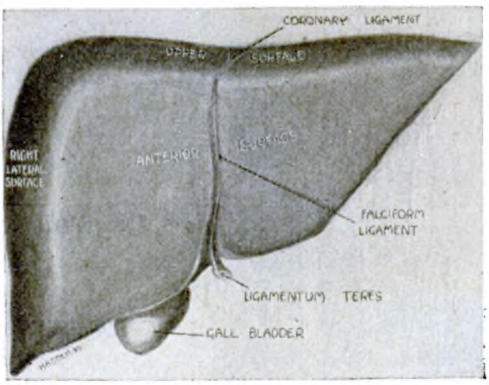

FIGURE 32.—The liver. (Cunningham modified)

Bile is partly an excretion which carries off certain waste products, and partly a secretion that plays an important part in the absorption of fats, and has been thought to limit putrefaction in the intestine to some extent. It is a thin, watery or a viscid, golden-yellow or dark olive colored liquid with a specific gravity varying from 1.050 to 1.10, a feebly alkaline reaction, and a complex composition. It is secreted normally in amounts of from 500 to 800 cc per day and contains a pigment, *bilirubin*, which is derived almost entirely from the breakdown of hæmoglobin in the liver. Although formed more or less continually in the liver cells, bile enters the intestine only during periods of digestion, being prevented from entering at other times because the opening of the common bile duct is closed, and it therefore backs up into the gall-bladder. Bile is collected from the liver cells by the *biliary ducts* which unite and gradually form larger and larger ducts that finally end in two main ducts which leave the liver and immediately join together to form the *hepatic duct*. The hepatic duct is soon joined by the *cystic duct* from the gall-bladder to form the *common bile duct* which enters into the duodenum with the pancreatic duct.

The functions of the liver are important and numerous and are as follows:

1. *Bile secreting.*—It manufactures and secretes bile.

2. *Glycogenic.*—It manufactures glycogen from monosaccharides brought to the liver from the digestive tract by the portal vein. Glycogen is stored in the liver and is reconverted into dextrose by the action of a special enzyme at such times as body activities require it. Because it has the same chemical formula as the general one given to starch $(C_6H_{10}O_5)_n$, glycogen is sometimes called "animal starch."

3. *Storing of fat.*—A certain amount of fat may be stored within the liver cells.

4. *Urea producing.*—Takes up nitrogenous waste products from the blood and converts them into urea, which is discharged back into the blood stream for elimination by the kidneys.

5. *Removes* by means of the bile certain other waste products, such as broken-down red corpuscles, disintegrated liver cells, and bile pigments.

6. The *liver* is considered as the source of fibrinogen and prothrombin. This organ is the site of origin of blood cells in the embryo.

The **pancreas** is a compound gland, long and irregularly prismatic in shape, and situated in the abdomen behind the stomach at about the level of the second lumbar vertebra (fig. 33). It has a head, which lies in the concavity

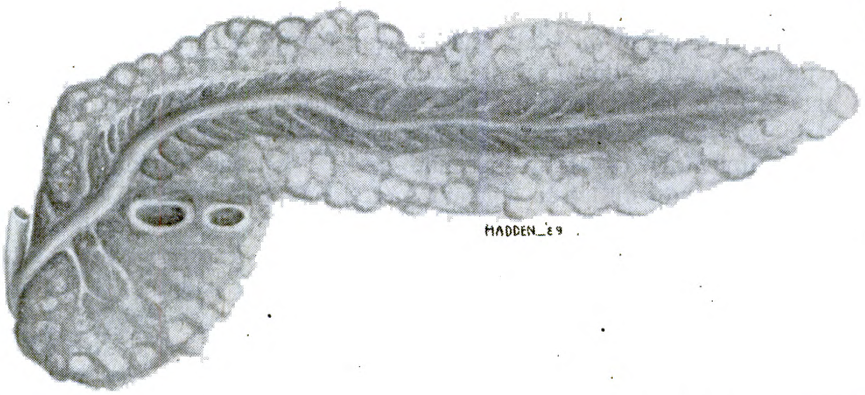

FIGURE 33.—Pancreas. (Mason, modified.)

of the duodenum, a neck, a body, and a tail, which touches the spleen. It is about 5 to 8 inches long, the three surfaces of the body are each about 1¼ inches wide, and it secretes the *pancreatic juice*, a digestive fluid which is one of the chief agents in intestinal digestion, and is carried to the duodenum by the *pancreatic duct*. Beginning in the tail of the gland this duct runs from left to right through the body and neck into the head where it leaves and enters into the duodenum with the common bile duct. During its course through the gland the pancreatic duct receives tributary ducts from all portions of the gland and increases in size until, near the duodenum, it is about as large as a goose quill. In the connective tissue between the lobules of the gland are small areas of modified glandular tissue having no ducts which are known as the *Islands of Langerhans* and secrete a substance which is discharged directly into the blood stream. The function of this secretion will be described in the section on ductless glands.

The process of digestion.

Before describing the process of digestion the substances used as foods must be briefly considered. **Foods** are those substances necessary to maintain the normal composition of the body by building up tissue or, by oxidation, supplying heat and energy. Foods include: 1. *Water;* 2. *Inorganic salts,* principally of sodium, calcium, potassium, magnesium, and iron; 3. *Vitamins,* organic chemical compounds essential to normal life and growth; 4. *Proteins,* nitrogen-containing substances, chiefly lean meats and leguminous vegetables; 5. *Carbohydrates,* starches and sugars; and 6. *Fats,* animal and vegetable oils and fats.

Water, inorganic salts, and vitamins are substances essential to life but have no energy-producing properties. Water and inorganic salts are necessary to maintain the normal composition of the tissues and complete withdrawal of either would cause the death of the organism. Vitamins are essential, in some as yet unknown way, to normal metabolism. The body's energy is derived from the proteins, carbohydrates, and fats, complex organic substances whose chemical structure is known in whole or in part. After being eaten these substances must undergo various chemical changes, generally spoken of as metabolism, before they can be utilized by the body. These chemical changes take place during the process known as digestion, break up the complex molecules of the substances into forms that the tissue cells are adjusted to act upon, and are attended by the production of heat. Foods are more fully discussed in the chapter on Diets and Messing for the Sick.

The process of digestion begins in the mouth and ends in the small intestine and is both mechanical and chemical. The mechanical features of the process include the chewing and grinding of the food, the passage of the food along the alimentary canal by muscular action, and the mixing of the food and its dilution and solution in aqueous secretions. The chemical changes that take place in food during digestion are brought about by the action of substances in the digestive fluids called *enzymes*, or *digestive ferments*, the latter term being used because they act upon foods used by the body.

In the definition for these substances given at the beginning of this section it is stated they effect the transformation of other compounds by *catalytic action*. By catalytic action, or catalysis, is meant a reaction or change produced in a substance by contact with another substance called the *catalytic agent* or *catalyst* which itself appears to remain unchanged as a result of the reaction it has produced. As the enzymes which bring about the changes in foods necessary for them to be used by the body are produced in living body cells they could well be termed organic catalysts.

The chemical composition of enzymes is complex, uncertain, or unknown, and although they all apparently contain nitrogen, and most of them sulfur, about all that can be said positively in regard to their chemical structure is that they are organic substances derived from living cells and are colloids or so closely associated with colloids that they have not been isolated in a noncolloidal state.

The action of enzymes is specific to a high degree, a given enzyme attacking only a certain compound or group of compounds. Consequently the enzymes that act upon carbohydrates cannot affect proteins or fats, those acting on proteins cannot affect fats, etc. Even closely related substances such as maltose and lactose seem to require their own specific enzyme.

The enzymes concerned in human digestion and nutrition are classified according to the nature of the substances upon which they act, the principal classes being shown in the following table:

CLASSES OF ENZYMES

Name	Action	Example
Proteolytic	Protein splitting	Pepsin of gastric juice; trypsin of pancreatic juice; erepsin of pancreatic and intestinal juices.
Amylolytic	Starch splitting	Ptyalin of saliva; amylase of pancreatic juice.
Lipolytic	Fat splitting	Lipase of pancreatic juice, of liver, connective tissue, etc.
Glycolytic	Sugar splitting	Maltase of saliva and of intestinal juice; invertase of intestinal juice; lactase of intestinal juice.
Coagulating	Convert soluble to insoluble proteins.	Rennin of gastric juice.

In the table which follows the enzymes that take part in the process of digestion are arranged in groups under the class title of the substances on which they act.

Name	Chiefly found in	Action
Acting on carbohydrates:		
Ptyalin	Saliva	Converts starch to sugar (maltose).
Amylase	Pancreatic juice	Do.
Invertase	Intestinal juice	Converts cane-sugar to dextrose and levulose.
Maltase	Saliva, intestinal juice, pancreatic juice.	Converts maltose (malt sugar) to dextrose.
Lactase	Intestinal juice	Converts lactose (milk sugar) to dextrose and galactose.
Acting on fats:		
Lipase (steapsin)	Pancreatic juice	Splits fats into fatty acids and glycerin. (Some of fatty acid and alkali forms soap which emulsifies fat.)
Acting on proteins:		
Pepsin	Gastric juice	Converts proteins to peptones and proteoses.
Trypsin	Pancreatic juice	Splits proteins, peptones, and proteoses into amino-acid compounds.
Erepsin	Pancreatic juice, intestinal juice.	Splits amino-acid compounds into their constituent amino-acids.
Rennin	Gastric juice	Precipitates casein from caseinogen and makes the curd of milk.

In the process of digestion, food is first taken into the mouth where *mastication* takes place. This is accomplished by the teeth and the lower jaw and after this mechanical dividing or grinding the food presents a larger surface for the action of the *saliva*. During mastication the saliva pours into the mouth from the salivary glands and is mixed with the food through the movements of the tongue and the muscles of the cheeks. This moistens and softens the food, and starch is converted into sugar through the action of the salivary enzymes, *ptyalin* and *maltase*. As found in the mouth, saliva is a colorless or opalescent, turbid, and viscid liquid with a specific gravity of about 1.003 and a neutral or slightly acid reaction. The enzyme pytalin converts starch to maltose (malt sugar), and maltase breaks up the maltose into dextrose. The presence of food in the mouth and the sight and smell of appetizing foods act as nerve stimuli to increase the amount of saliva necessary for mouth digestion.

The food taken into the mouth has there been reduced to a consistency suitable for swallowing and has been formed into what is known as a *bolus*. By deglutition, or swallowing, the bolus passes from the mouth to the pharynx and thence into the œsophagus through which it is carried into the stomach. The act of swallowing is largely voluntary but the final stage and the passage of the bolus through the pharynx and œsophagus is the result of involuntary muscular action. The musculature of the œsophagus causes a contraction of the tube to occur immediately after the passage of the bolus which follows the bolus from above downward like a wave, finally forcing it through the cardiac opening of the stomach. This wave-like contraction is called *peristalsis*.

In the stomach the food which has been swallowed is thoroughly mixed with the gastric juice by muscular movements of the stomach walls. These movements, somewhat peristaltic in character, not only mix the food and the gastric juice but eject the liquefied portions of the food into the duodenum. As digestion proceeds in the stomach the food becomes a thin, liquid mass known as *chyme*, which periodically passes through the pylorus into the duodenum.

In the mucous membrane of the stomach are myriads of simple glands called *gastric glands* which secrete the gastric juice, a thin, colorless or nearly color-

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less liquid with a specific gravity of about 1.002 to 1.003, a strongly acid reaction because of the presence in it of *hydrochloric acid*, and a characteristic odor. Two enzymes, *pepsin* and *rennin*, and perhaps a third, *lipase*, are found in the gastric juice. The flow of gastric juice occurs partly in response to nerve impulses sent to the stomach as a result principally of the sensory impressions of taste and smell received in the brain, and partly by the presence of chemical substances in the stomach itself. Hard work should not be performed or strenuous exercise taken immediately after eating as this retards digestion in the stomach chiefly by checking the flow of gastric juice, with gastric distress and possibly vomiting as a result. Nor should a hearty meal be eaten when physically exhausted because the nervous, circulatory and digestive systems cannot properly perform their parts in the process of digestion. The food on mixing with the gastric juice becomes acid in reaction. The **hydrochloric acid** in the gastric juice stops the action of pytalin, aids in coagulating proteins, activates the enzyme pepsin which is secreted in an inactive form, *pepsinogen*, and seems to favor relaxation of the pyloric sphincter, which remains closed after each ejection of chyme until the acidity of the ejected chyme in the duodenum has been neutralized. The enzyme **pepsin** prepares the proteins of the food for complete digestion by breaking them down into simpler chemical compounds known as *peptones* and *proteoses*. **Rennin,** which is present in many persons only during early life, precipitates *casein* from the *caseinogen* in milk and causes the milk to clot, or curdle, and form a curd. **Lipase,** which when present is in small amounts, has very little activity in the stomach, its action probably being the splitting up of the finely emulsified fat found in milk.

The **chyme** on passing into the duodenum from the stomach consists of water, inorganic salts, partially digested foods, and the indigestible portion of meats, cereals, and fruits. The acid character of the chyme causes the secretion and discharge of the intestinal fluids secreted by glands in the mucous membrane of the duodenum and of the small intestine, the pancreatic juice, and the bile. The intestinal fluids, which are alkaline in reaction, exert a neutralizing and precipitating influence on the various constituents of the chyme and as soon as this occurs gastric digestion ends and intestinal digestion starts.

Beginning in the duodenum, intestinal digestion is largely completed by the time the food reaches the ileo-cæcal valve and produces the important changes in the food necessary for its absorption. In intestinal digestion the partially digested food received from the stomach is subjected to the action of the *pancreatic juice*, the *intestinal juice*, and the *bile*. These secretions mix with the food from the duodenum on and they act at the same time.

The **pancreatic juice** in man is a thin, limpid liquid with a specific gravity of about 1.0075 and an alkaline reaction. It is undoubtedly the most important digestive fluid in the body and contains four enzymes, *trypsin* and *erepsin*, proteolytic enzymes, *amylase* (also known as amylopsin), a starch-splitting enzyme, and *lipase* (also known as steapsin), a fat-splitting enzyme. Trypsin, like pepsin, is secreted in an inactive form *trypsinogen*, which is activated by *enterokinase*, a constituent of the intestinal juice. The erepsin in the pancreatic juice is similar to that in the intestinal juice. Lipase is aided and facilitated in its action by the presence of bile. The action of the pancreatic enzymes is shown in the table on page 59.

Human bile plays an important part in the digestion and absorption of fats as it accelerates the action of lipase and perhaps of amylase, and helps in the neutralizing of the hydrochloric acid of the gastric juice. It is also considered to aid in lubricating the intestine to facilitate the passage of indigestible and waste matter.

Peristaltic movement forces the contents of the small intestine along until finally they enter the large intestine through the ileo-cæcal valve, at which time digestion is virtually complete. When the contents of the small intestine enter the large intestine they contain some unabsorbed food material, and, as they also contain digestive enzymes received in the small intestine, it is probable that digestion and absorption continue for a time in the large intestine. The indigestible waste material, combined with certain waste substances from the bile and intestinal secretions, passes slowly along the large intestine by peristaltic movement and rapidly loses its water content by absorption until, by the time it reaches the descending colon it has acquired the consistency of *fæces.* When the fæces reach the terminal portion of the large intestine they are ready to be expelled from the body by the act of defæcation.

By digestion the carbohydrates, proteins, and fats contained in the various foods that have been eaten have been changed into substances of simpler chemical composition. Starches and compound sugars have been changed into simple sugars, proteins have been broken down into their constituent amino-acids, and fats have been finely emulsified and split into fatty acids and glycerin, all of which are forms suitable for absorption.

In physiology **absorption** is a term to describe the passage of digested foods from the alimentary canal into the blood or lymph. The absorption of food takes place principally from the small intestine. There is some food absorption and a large absorption of water from the large intestine, and little or no absorption from the stomach. Absorption from the small intestine takes place by two paths: 1. By the *capillaries of the villi* to the blood stream; and 2. By the *lymphatics* to the thoracic duct and the superior vena cava. The products of fat digestion are taken up chiefly by the lymph capillaries, or lacteals, in the villi and carried by the lymph stream into the thoracic duct and finally into the blood stream at the junction of the left internal jugular and the left subclavian veins. A small amount of fat is absorbed by the blood capillaries, part of which is appropriated by the liver for its own use and storage. The products of protein and carbohydrate digestion are taken up by the blood in the capillaries of the villi and carried through the portal circulation to the liver. In the liver the excess of dextrose (simple sugar) is withdrawn and changed to *glycogen* by the action of the liver cells, the amount of sugar in the blood remaining constant. Some of the amino-acids are also converted to glycogen by the action of the liver cells with the formation of urea, which is carried in the blood to be excreted by the kidneys. The glycogen is stored in the liver to be liberated again as dextrose when needed by the body.

THE SPLEEN AND OTHER DUCTLESS GLANDS

The term **ductless glands** is applied to those organs whose function is to produce special secretions containing *hormones,* which are discharged into the blood or the lymph. These organs are also called *endocrine glands* or *glands of internal secretion* and, as previously stated, are of glandular structure and have no ducts. A **hormone** is a chemical substance produced in a more or less distant organ which, carried by the blood or lymph to a functionally associated organ, excites the latter to activity. The glands generally spoken of as ductless glands are the *thyroid,* the *parathyroid,* the *thymus,* the *suprarenals,* the *pituitary body,* or *hypophysis,* and the *pineal body,* or *epiphysis.* The spleen, though it has no ducts, has not been found to have an internal secretion, and therefore, while anatomically a ductless gland, physiologically it is not a gland of internal secretion. Some other glands in the body that have

ducts, as the pancreas and the gonads (testes in the male, ovaries in the female), also form internal secretions that are discharged directly into the blood and therefore act as ductless glands in addition to their more obvious functions. There are a few other ductless glands which will not be described in this section.

The **spleen** is situated in the upper left part of the abdomen directly beneath the diaphragm in front of the upper part of the left kidney and behind and to the left of the stomach. Its border is roughly oval or circular in outline, its size varies greatly, and its average weight is from 5 to 8 ounces. It is a soft, highly-elastic, contractile organ, purplish in color, and composed of a fibrous capsule containing a soft substance called *pulp* in which nodules of lymph tissue are embedded. There are no capillaries in the spleen, the blood escaping from the arterioles into the pulp and being collected from the pulp by the small venules. The spleen is known to be active in the destruction of defective blood cells, both red and white, as well as being the source of some of the lymphocytes of the blood stream. It undoubtedly has other functions not now definitely known. In some diseases, as chronic malaria, it becomes greatly enlarged.

The **thyroid gland** is a highly vascular body situated anteriorly in the neck at the junction of the trachea with the larynx, and its tissue consists of spherical vesicles lined with epithelium and containing a fluid called *colloidal material*. It is composed of two conical *lobes* connected across the median line by a narrow strand of gland tissue called the *isthmus*, one lobe lying on each side of the larynx and extending upward. The gland secrets a substance called *thyroxin* which contains a large percentage of iodine and has a marked influence on body growth and on nervous stability. Complete removal of this gland, leaving the parathyroids uninjured, does not cause death but does cause marked changes in metabolism and is usually followed by a state of chronic malnutrition or *cachexia*. *Cretinism* is the result of a congenital defect or atrophy of the thyroid gland, which causes the arrest of skeletal and mental development. On atrophy of this gland in the adult, a similar phenomenon called *myxœdema* results, the body becomes puffed and pasty, and the mentality blunted. In *hyper-thyroidism*, or *goiter*, there is an extreme nervousness, increased metabolism, quickened heart action, and in some cases protrusion of the eyeballs (*exophthalmos*).

The **parathyroids**, usually four in number, are small grain-like bodies located on or near the posterior surface of the lobes of the thyroid, two on each side. The internal secretion which they furnish regulates calcium metabolism which is so essential in bones, blood, and other tissues, and is believed to aid in neutralizing certain toxic substances. Complete removal of the parathyroids is followed by acutely toxic results, muscular tetany, and death.

The **thymus** is located in the thorax posterior to the sternum and varies greatly in size in different individuals and at different ages. It is considered to consist of two lobes, one on each side of the midline, and to reach its maximum size in childhood. While it undergoes atrophy after puberty it does not entirely disappear. Its function is obscure but it is believed it exerts an influence on body growth and the development of the reproductive organs.

The **suprarenals**, or *adrenal glands*, are two flattened bodies situated in the back part of the abdomen which lie like caps over the upper pole of each kidney. These glands consist of two portions, an inner, highly vascular mass of tissue called the *medulla* enclosed within an outer portion, or capsule, of cortical substance called the *cortex*. The cortex in turn is surrounded by a capsule of fibrous tissue. Each portion has a separate secretion and function. The

secretion of the medulla, *adrenalin*, or *epinephrine*, is the better known and has a marked effect on the tone of the heart and the blood vessels. It increases blood pressure by constricting the blood vessels and slowing and increasing the force of the heart beat. Its constricting action on blood vessels causes it to be used in controlling hæmorrhage. *Cortin*, the secretion of the cortex, regulates important phases of the mineral and water metabolism of the body, and appears to be of great value in the treatment of Addison's disease. From the cortex was first isolated the substance known as *ascorbic acid*, which is the antiscorbutic vitamin C. Removal of the cortex results in death.

The **pituitary body**, or *hypophysis*, is a small, oval-shaped gland attached to the base of the brain and situated in a depression in the sphenoid bone. It consists of an anterior lobe of glandular structure and a posterior lobe composed chiefly of connective tissue, blood vessels, and nerve cells and to which a glandular portion, the *pars intermedia*, is attached. The anterior lobe is larger than the posterior, which it partly encircles, and has been called the "master gland" as it appears to influence the activity of most of the other glands of internal secretion. This gland, though its size is small and its gross structure simple, has the most complex function of the glands of internal secretion. In its secretion are a great number of hormones, some of which are far from being definitely identified. In the anterior lobe, hormones influencing sex, growth, thyroid metabolism, and carbohydrate metabolism are known to be present, and in the posterior lobe hormones stimulating contractions of nonstriated muscles, constricting arteries and raising blood pressure, and with anti-diuretic action have been found. Over or under production of the growth principle in the secretion of the anterior lobe results in pituitary giants or dwarfs.

The **pineal body**, or *epiphysis*, is a small, fir-cone-shaped gland about the size of a cherry stone situated near the pituitary body but above and back of it. Little is known of the function of the pineal gland, but the general conclusion from evidence now at hand is that it has an internal secretion which counteracts at least some of the functions of the pituitary, particularly the stimulation of the gonads. It is also necessary for the development of the eyeball, very small eyes occurring in its absence.

The **pancreas**, mentioned elsewhere as producing digestive enzymes, also produces, from areas of specialized tissue called the Islands of Langerhans, a hormone called *insulin*, which like other products of the glands of internal secretion, is poured directly into the blood. Insulin is essential in the regulation of carbohydrate metabolism. An insufficiency, relative or absolute, results in the condition called *diabetes*.

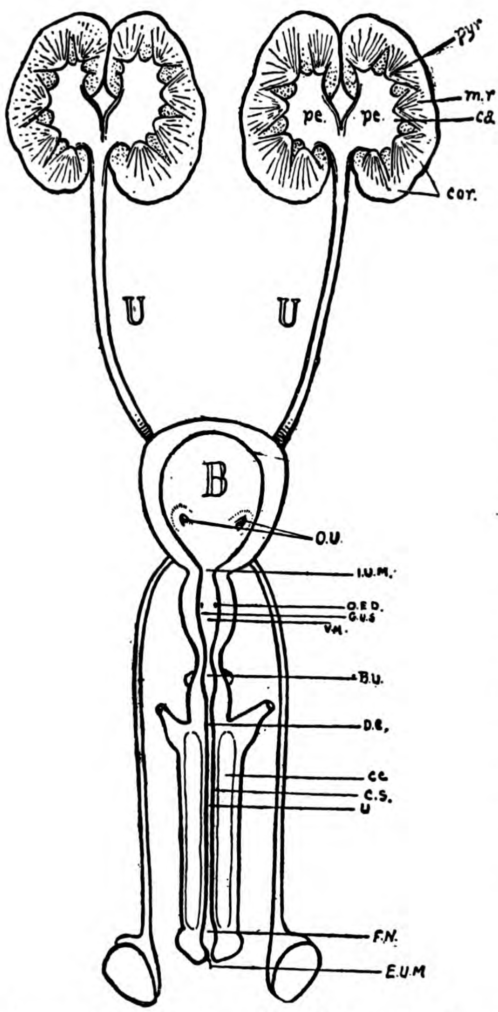
The **gonads**, sex glands, male, *testes*, and female, *ovaries*, each produce, in addition to reproductive cells (spermatozoa and ova), an internal secretion which is responsible for the development of appropriate secondary sex characteristics in the individual.

THE EXCRETIONS.

The waste products resulting from the activities of the body are called *excretions* and are discharged to the exterior by organs known as *excretory organs*, some of which are arranged in systems. The discharge of the waste products of the body is called *excretion* and takes place by means of: 1. The *urinary system*, which eliminates water, and certain organic and inorganic waste products; 2. The *skin*, which eliminates water, organic and inorganic waste materials by means of perspiration; 3. The *lungs*, which eliminate certain gaseous waste products, such as carbon dioxide, water vapor, and small

amounts of nitrogen; and 4. The *alimentary canal*, which eliminates the residue remaining after digestion and the waste products discharged into it.

Normal urine of man varies in color from a pale yellow to a brownish hue, is acid in reaction, and has a specific gravity ranging from 1.015 to 1.025. The color varies according to the quantity excreted, being pale or light when the quantity is large, and dark when the quantity is small and the concentration of solids is greater. Various foods and medicinal substances also affect the



pe. The pelvis of the kidney.

cor. The cortex, the part between the cortex and the pelvis being the medullary portion.

pyr. Pyramid.

ca. The calices.

m. r. The medullary rays.

U. The ureters.

B. The bladder.

o. u. The ureteral openings.

i. u. m. The internal urinary meatus.

o. e. d. The openings of the ejaculatory ducts in the prostatic urethra.

g. u. s. The genitourinary sinus.

v. m. The veru montanum.

b. u. The bulbous urethra.

d. c. Openings of the ducts of Cowper's glands.

c. c. Corpus cavernosum.

c. s. Corpus spongiosum.

u. Urethra.

f. n. Fossa navicularis.

e. u. m. External urinary meatus.

FIGURE 34.—Anterior view of the opened genitourinary tract in the male. (Guiteras.)

color of the urine. The degree of acidity varies at different periods of the day and is affected by the character of the individual's food or by medicinal substances taken. The average daily output is from 40 to 50 fluidounces but may be more or less, depending upon many factors, among which may be mentioned atmospheric temperature, the intake of fluids, disease, medicinal substances taken, and other types of elimination of fluids, as in hæmorrhage, perspiration, diarrhœa, and vomiting. Urine has a characteristic odor which is influenced by disease, vegetable foods, and other substances. The chemical composition of urine is very complex and is determined partly by tissue metabolism and partly by the quantity and quality of foods consumed and metabo-

lized. Ordinarily it is composed of about 95 per cent of water and 5 per cent of solids comprised of nitrogenous waste products and organic and inorganic salts. The chief nitrogenous constituent of urine is *urea* which is present to the extent of about 2 per cent. Other nitrogen compounds are present in minor quantities. The inorganic salts are those of sodium, calcium, ammonium, potassium, and magnesium, the organic salts are lactates, acetates, and small amounts of formates. Certain abnormal constituents as albumin, sugar, indican, acetone, casts, and blood may be found under pathological conditions.

The urinary system consists of the *kidneys*, the *ureters*, the *bladder*, and the *urethra* (fig. 34).

The **kidneys** are two large, glandular organs situated in the posterior part of the abdominal cavity, behind the peritoneum, one on each side of the lower,

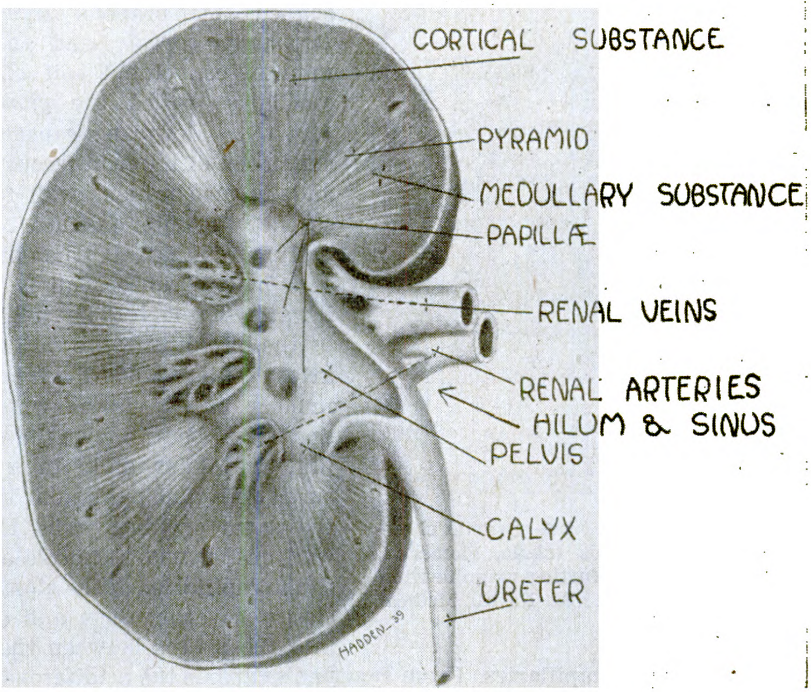


FIGURE 35.—Section of kidney. (U. S. Naval Medical School.)

movable portion of the spinal column. They extend from about the level of the twelfth thoracic to that of the third lumbar vertabræ, the inferior end usually being from 1¼ to 2 inches above the highest part of the crest of the ilium, and the right kidney slightly lower than the left. These organs (fig. 35) are bean-shaped and each is about 4½ inches long, 2 inches wide, and 1¼ inches thick. On the concave side of each is a deep, notch-like depression called the *hilum*, through which the blood vessels and nerves enter and leave the kidney. The hilum extends inward into the kidney to form the narrow space known as the *sinus of the kidney*. Each kidney is surrounded by a thin fibrous capsule and lies embedded in a mass of soft fatty tissue. The *parenchyma*, or specialized glandular tissue, of the kidney is dense and friable, and consists of an inner portion called the *medullary substance*, or *medulla*, and an outer portion called the *cortical substance*, or *cortex*. The medullary substance surrounds the sinus of the kidney and appears largely in the form of conical masses known as *renal pyramids*, or *pyramids*, whose apices project into the sinus to form

small conical elevations called *renal papillæ,* or *papillæ,* whose rounded ends are pierced by minute openings called *foramina papillaria* that are the terminal apertures of the tubules of the kidney. Two or three and sometimes six or more pyramids end in one papilla, which number from 6 to 18 and cause the floor of the sinus to be uneven. The bases of the pyramids are covered and also separated from the surface of the kidney by a layer of the cortical substance of the kidney, which also extends inward towards the sinus, between the pyramids, in columns known as *renal columns.* In the cortical substance are an immense number of tubules called *uriniferous tubules* and thousands of small structures known as *Malpighian bodies* or *renal corpuscles* (fig. 36). These bodies are located in the cortical substance of the kidney and consist of an outer, spherical-shaped, membranous sac called *Bowman's capsule,* and an inner, minute, convoluted coil of blood capillaries called the *glomerulus* (fig. 36). Bowman's capsule is an expansion of the uriniferous tubule and its membranous wall folds in so that its outer surface becomes an inner surface, as when one part of a hollow rubber ball is pushed inward. Through the opening made by the infolding of the wall a small artery enters and divides into a number of capillaries which coil and twist about to form the glomerulus and later unite in a single small vein that passes out through the same opening. The infolded wall of Bowman's capsule adheres to the capillaries of the glomerulus, closely covering them and dipping into the spaces between the small coils of the glomerular capillaries. From Bowman's capsule the uriniferous tubule immediately continues through the cortical and medullary substances until it terminates in the opening in the papilla with which it communicates. The uriniferous tubules, which may be roughly separated into a secreting part lined with several types of epithelial cells and a collecting part, are partly convoluted and partly straight and regular, and run a very complicated course before the collecting part begins in the pyramids. The collecting part of the tubule in the pyramids is straight and empties into the kidney pelvis, there discharging the urine collected. The blood supply of the kidneys is through the renal arteries which give off branches that, as they pass through the kidney substance, divide repeatedly into smaller branches each of which, with a few exceptions, ends in a glomerulus. The venous return is by the renal veins.

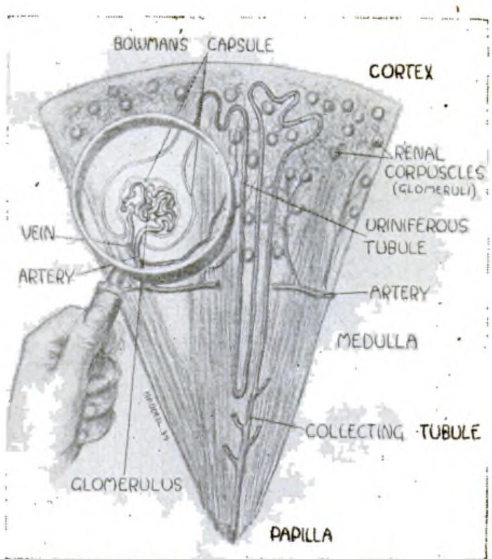


FIGURE 36.—Schema of a renal pyramid showing enlarged uriniferous tubule, glomeruli, and blood supply, with further magnification of a glomerulus. (U. S. Naval Medical School.)

The **function of the kidneys** is to remove certain waste materials from the blood and excrete them in the aqueous solution known as urine, thereby preventing the waste materials from accumulating in the blood and keeping its composition constant. They also play an important part in maintaining the normal, slightly alkaline reaction of the blood by excreting enough of substances in the blood that might alter its reaction to reduce their quantity to

the normal level. For example, should the reaction of the blood tend to become too alkaline, the kidneys will excrete more alkali in the salts in the urine. Also, when the presence of more acid substances in the blood tends to make its reaction less alkaline, they excrete more acid. Likewise, although its removal is not concerned with the reaction of the blood, the kidneys will remove all excess sugar present in the blood. Through the kidneys the greatest part of nitrogenous waste products is excreted, that excreted elsewhere being almost negligible in quantity.

The process by which substances are removed from the blood and excreted in the urine is not definitely known but the generally accepted theory is that it is a process of filtration, reabsorption, and secretion. All the substances present in the blood plasma except protein filter through the infolded wall of Bowman's capsule into the sac-like cavity communicating with the uriniferous tubule. The liquid that seeps through the capsule is known as the *filtrate* and consists of blood plasma without any protein. This filtrate as it passes along the course of the uriniferous tubule becomes altered in composition by the selective action of the epithelial cells lining the tubule.

The selective action of the epithelium of the tubule consists very largely of a reabsorption of those substances that, at the time, are needed by the blood to maintain its normal composition, i. e., a composition having the proper aqueous dilution, the proper acid-base balance, the proper sugar concentration, etc. Also, by this mechanism those substances that are not needed in the operation of the body metabolism are thrown off. Whether or not a certain substance is needed at a given time depends on conditions within the body at that time. Thus, when the body needs water, as may occur as a result of limited intake or from increased loss through sweating, diarrhœa, or copious vomiting, more water is reabsorbed from the filtrate and as a result the urine contains less water and its specific gravity rises. On the other hand, when the body has an excess of water, the urine contains more water and its specific gravity lowers. Similarly, if the body has need of sodium chloride that substance is selected out and reabsorbed from the filtrate in the tubule with the result that little is excreted in the urine. This occurs particularly when sodium chloride is absent from the diet. Also, all sugar in the filtrate is normally reabsorbed in the tubule with the result that none is excreted in the urine. In blood plasma there is normally about 0.03 per cent of urea present while in urine there is nearly 67 times as much, or about 2.0 per cent. This great increase is largely due to concentrating the urea contained in a very large amount of filtrate in a relatively small amount of urine.

In addition to the absorption taking place in the uriniferous tubule there is good experimental evidence showing that the epithelium which lines the tubule actually secretes some of the urinary constitutents, particularly the ammonium salts found in urine.

Besides removing from the blood the waste products of normal body metabolism the kidneys also are able to remove surprisingly large amounts of foreign substances of a poisonous nature that may find their way into the blood stream. Outstanding examples of substances so removed are mercury, various barbituric-acid derivatives, and alcohol. Most medicinal substances given in treatment are ultimately eliminated from the body through the kidneys.

These activities of the kidneys show them to be organs extremely vital to the well-being of the body. If they fail to perform their vital functions, the composition of the urine changes, substances that should be are not removed from the blood, and those substances rapidly build up to a concentration in the blood that results in toxic conditions. One of the most familiar conditions

manifesting a disturbance of kidney function is *albuminuria* which occurs when Bowman's capsule fails to prevent protein from passing through it. When waste products are retained in the blood because of failure of the kidneys to remove them, they quickly build up to a concentration in the blood that produces toxic effects. The acid-base balance is seriously disturbed and an excess of urea and other waste products accumulates. This condition is known as *uræmia.*

The **ureters** (fig. 35) are two musculo-membranous tubes about 15 to 18 inches long, that begin above in a thin-walled, funnel-shaped expansion called the *pelvis* which lies partly within and partly without the sinus of the kidney. The part outside of the sinus gradually decreases in size until at about the level of the inferior end of the kidney its diameter is about that of a goose quill. The part within the sinus contains several cup-like divisions called *renal calyces,* or *calyces,* which enclose the papillæ and receive the urine, which enters them through the openings in the papillæ. The ureters connect the kidney and the bladder, leaving the kidney at the hilum and entering the bladder at the lower and back portion of the organ, where they deliver to the bladder the excretion of the kidneys. The course of the ureters through the muscular walls of the bladder is oblique so that when the bladder is distended the coats of the ureters are approximated in such a manner that regurgitation of urine from the bladder is prevented.

The **urinary bladder** (fig. 34) is a musculo-membranous sac situated in the pelvis just behind the pubis, and does not, under normal conditions, extend above the upper border of the symphysis. It acts as a reservoir for urine until such time as micturition is convenient. When moderately distended the bladder holds about 1 pint. Upon the inner surface of the bladder in the upper part, or *fundus,* the mucous membrane is thrown into folds or *rugæ.* The lower portion presents a comparatively smooth triangular surface, known as the *vesical trigone,* outlined by the openings of the two ureters and the urethra.

Micturition, or the act of voiding urine, is an involuntary mechanism controlled partly by volition.

The **urethra** (fig. 34) is a membranous tube passing from the bladder along the under surface of the penis to the distal end of that organ where it terminates in the *meatus.* It serves to convey the urine and, in the male, the secretions of the genital glands, to the exterior. In the male it is about 8 inches long, and is divided into three parts, the *prostatic,* the *membranous,* and the *penile* portions. The prostatic urethra, about 1 inch in length, is surrounded by the prostate gland and contains the orifices of the prostatic and the ejaculatory ducts. In this portion the diameter of the urethra is the largest. The membranous urethra is about one-half inch in length and consists of that portion which pierces the urogenital diaphragm. The penile urethra is the longest portion and lies along the base of the penis, extending to its external opening, the urinary meatus. (See section on Genito-urinary and Venereal Diseases.)

The **perspiration,** or *sweat,* excreted by the sweat glands of the skin, is a clear, colorless, watery liquid with a specific gravity of about 1.004 and a slightly acid reaction. It has a salty taste and a distinctive, rancid odor or none at all. Perspiration is excreted continuously, taking place so gradually that it evaporates as fast as it is formed when it is known as *insensible perspiration,* or, under exposure to great heat and exercise, so rapidly that evaporation does not take care of it, and it is then known as *sensible perspiration.* Normally about 1 quart of this fluid is excreted daily, but the amount varies widely with atmospheric temperature and humidity, and the amount

of exercise taken. It consists chiefly of water with small quantities of salts, fatty acids, urea, and carbon dioxide.

The **skin** is a tough elastic membrane forming the outer covering of the body, and contains certain appendages as the hair and nails. Certain glands, as the sweat and the sebaceous glands, discharge their secretions upon the surface of the skin. (Fig. 37).

The skin is made up of two principal layers, the *epidermis*, or *cuticle*, and the *derma*, or *true skin* (*cutis vera*). The **epidermis** consists of stratified squamous epithelium and may be divided into two layers, the superficial layer being horny and hard, and the inner layer, known as the germinative layer, consisting of soft protoplasmic cells.

The **derma** is a highly sensitive and vascular layer of connective tissue, containing blood vessels, hair follicles, sweat and sebaceous glands, and nerve endings.

The **sweat glands** are coiled tubular glands, the coils of which lie embedded in the derma and surround a small tuft of capillaries. These glands are located in the subcutaneous tissue and open by a duct upon the surface of the skin. The sweat glands serve as excretory organs, excreting the sweat or perspiration. The **sebaceous glands** are compound sacular glands, the ducts of which open about the hair shaft. These glands secrete an oily substance, *sebum*, which keeps the skin soft and pliable. The true skin is well supplied with specialized nerve endings which carry impressions of touch, heat, cold, and pain. The true skin also contains motor nerves to blood vessels, and secretory nerve fibers to the glands.

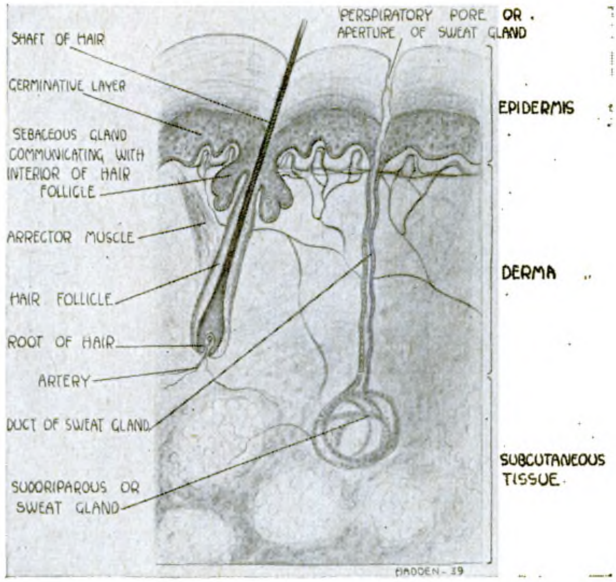


FIGURE 37.—Perpendicular section of skin. (Mason, modified.)

The skin serves as a protective covering to aid in the preservation of body temperature, and as an excretory organ. It contains the nerve endings previously mentioned.

THE MALE REPRODUCTIVE ORGANS

The male genital organs consist of the *testes*, the *epididymis*, the *scrotum*, *ductus deferens*, *seminal vesicles*, *prostate*, *bulbo-urethral glands*, *urethra*, and the *penis*. (fig. 38).

The **testes** are two glandular organs suspended from the inguinal region by the spermatic cord and surrounded and supported by a musculo-membranous sac covered with skin, the **scrotum**. The testicle proper is somewhat oval in shape and is composed of tubular glands held together by connective tissue. These glands form the male generative cells, the *spermatozoa*. The interstitial cells of the testis produce an internal secretion which promotes the development of

masculine characteristics. The tubules of the testicles unite to form a single tube which lies as a tortuous mass called the **epididymis** on the posterior surface of the testicle and connects with the ductus deferens.

The **ductus deferens** or *vas deferens*, is the excretory duct of the testicle and runs in the spermatic cord through the inguinal canal into the abdomen, thence extra-peritoneally on a convergent course to the seminal vesicles. The **spermatic cord** forms the pedicle of each testicle and extends from the internal abdominal ring to the back of the testis, and is made up of the ductus deferens, spermatic arteries and veins, lymphatics, nerves, cremasteric muscle and connective tissue.

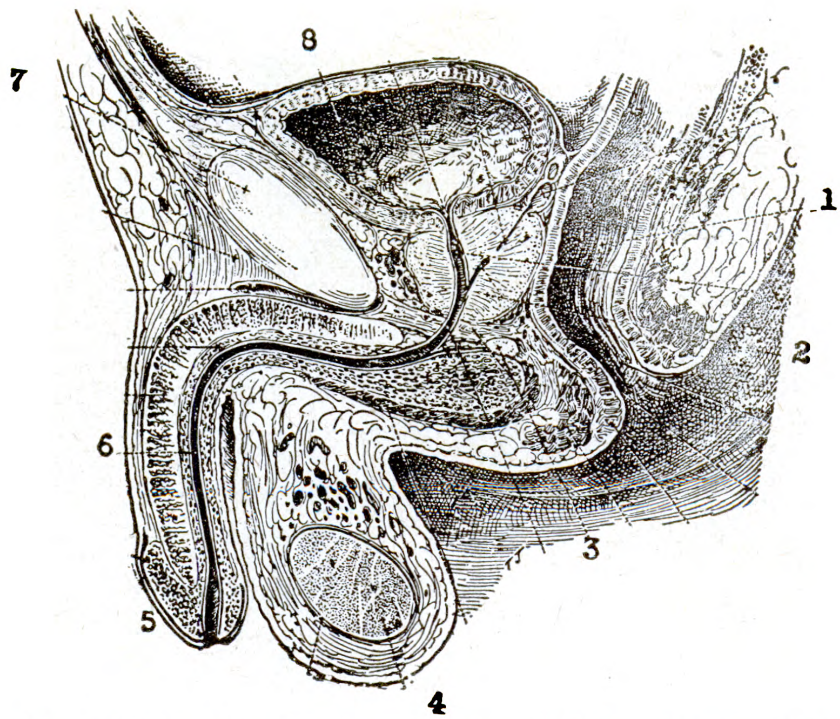


FIGURE 38.—Section through male generative organs and bladder. 1, Rectum, 2, prostate; 3, bulbo-urethral gland; 4, testicle; 5, glans penis; 6, urethra; 7, symphysis pubis; 8, bladder. (Manual of Surgical Anatomy, U. S. Army, modified.)

The **seminal vesicles** are two glandular pouches between the bladder and rectum and unite with the ductus deferens to form the *ejaculatory duct*. These vesicles serve as a reservoir for the *semen* and add a secretion of their own. The ejaculatory ducts pass from the seminal vesicles between the lobes of the prostate gland and open into the floor of the prostatic urethra.

The **prostate gland** is a partly glandular and partly muscular organ that surrounds the first portion of the urethra and resembles a horse-chestnut in form. The glandular and muscular tissue of this gland is surrounded by a dense fibrous capsule. It secretes a fluid which is an essential element of the semen. The **bulbo-urethral or Cowper's glands** are two small bodies about the size of a pea situated one on each side of the membranous urethra and opening into it. They secrete a fluid which forms part of the seminal fluid.

The **penis** consists of three more or less cylindrical bodies composed largely of erectile tissue. The two *corpora cavernosa* lie above the *corpus spongiosum* which contains the urethra. The *glans penis*, forming the distal end of the

penis, is continuous with the corpus spongiosum and contains the external opening of the urethra, the *meatus*, or *urinary meatus*. The covering of the shaft of the penis is loose skin, but that portion reflected over the glans penis is a thin layer of skin lined with mucous membrane, and is called the *prepuce*.

The semen is a fluid made up of the secretions of the bulbo-urethral glands, the prostate, the seminal vesicles, and the testes.

THE NERVOUS SYSTEM

In order that the subject matter which is to follow may perhaps be better understood it is considered advisable to briefly describe the means by which the lower forms of animal life react to different conditions.

The lowest form of animal life, the unicellular animal organism such as the *Amœba*, possesses no distinctive nervous system but adapts itself to its surroundings by reason of the property of irritability which is inherent in the protoplasm of which it is composed. The single-cell animal moves about and carries out its processes of metabolism and reproduction entirely within and by itself and always reacts in the same way to any specific stimulus.

A little higher form of animal life, the *Metazoon*, has a soft, semifluid body of protoplasm consisting of groups of cells which stick together. Most of these cells, originally derived from a single parent cell, have lost their characteristics as individual cells and become specialized for certain functions. Some are specialized so that they link the different parts of the body of this water-dwelling animal together with a primitive nervous system which deals with outside impressions, brings about necessary movements, and controls various living activities. Other cells are specialized to form a supporting substance (primitive skeleton) and others are specialized to provide for movement (primitive muscles). In all parts of the outer supporting substance are cells which are specialized to receive external stimuli and are known as *sensory* or *receptor cells*. From the receptor cells extend two elongated portions called *processes*. One, the *peripheral process*, passes toward the surface and may even pass beyond it, the other, called the *central process*, passes inward into the body and connects with a network of cells of the nervous system called *connector cells*. The connector cells communicate with each other by processes and have other processes reaching still deeper into the body and connecting with *motor* or *effector cells* which have processes distributed to the primitive muscles of the animal. There is thus provided a means by which a sensation or impression of danger received by a receptor cell can be carried to a connector cell and thence, through the network of connector cells, to a number of motor cells. As a result of stimulation of the motor cells there occurs a general response of the primitive muscles and the animal moves away from the point of danger. Such a general muscular response to a local stimulus is always the same if conditions are the same.

In producing the movement just described three basic nerve elements have been shown to exist: 1. The *receptor* or *sensory cell;* 2. The network of *connector cells;* and 3. The *motor* or *effector cells*. These basic elements are found in the nervous systems of all forms of animal life higher than the Metazoon, with such modifications as are necessary to permit a particular type of animal to carry out its purpose in life.

When the higher stage in animal life represented by the earthworm, or *Lumbricus*, has been reached there has evolved from the primitive nervous system one in which there is a *central, controlling part* quite distinct from a *peripheral portion* of nerve fibers carrying impulses to or from the central part. In the earthworm this central part consists of a *nerve-cord* running

longitudinally through the entire length of the body, in each segment of which the nerve-cord is slightly swollen or enlarged on each side. These enlargements are collections of nerve cells called *ganglia* from each of which bundles of nerve fibers called *nerves* pass off to each side. Some of these nerves are *motor* and are connected with muscles; others are *sensory* and end in *receptor* or *sensory cells* in the covering of the body. Close to the front end of the worm is located a single pair of ganglia called the *cerebral ganglia* which are connected with each other by a bridge of nerve fibers. From the side of each cerebral ganglion a strand of nerve fibers curves around the side of the worm's alimentary canal and connects with the first ganglion of the nerve-cord. In the more highly developed animals the cerebral ganglia in the worm may be said to be represented by the brain, the nerve-cord by the spinal cord, and the ganglia on the nerve-cord by the pairs of spinal nerves.

In the higher animals modification and evolution of the primitive nervous system of the Metazoon has proceeded to the point where a *central nervous system* consisting of the *brain* and *spinal cord* and a *peripheral nervous system* consisting of the *spinal nerves* have been developed. The primitive connector cells and their processes and the primitive motor cells without their processes have collected to form the central nervous system and ganglia on sensory nerves. *Nerves* have evolved, the processes of the primitive receptor or sensory cells forming *sensory* or *afferent nerves* which pass into the central nervous system while the processes of the primitive motor or effector cells have formed *motor* or *efferent nerves* which pass out of the central nervous system. If, for convenience, both sensory and motor nerve fibers are carried in the same nerve trunk, that nerve trunk is known as a *mixed nerve*. The cranial nerves arising from the brain and the spinal nerves arising from the spinal cord are typical examples of mixed nerves. With this evolution of the nervous system there have been developed special receptors for the functions of sight, smell, hearing, etc., and in the highest forms of animal life certain parts of the brain have enlarged to enable it to properly control the many complex functions and movements of the body containing that brain.

The ability of the human organism to adapt itself to its surroundings or environment, to coordinate and regulate the activities of its various parts so that they work harmoniously together, and to reason, is due solely to the presence in it of nerve tissue, which, as previously stated, is the most highly specialized tissue in the body. This tissue is present in every part of the body in the form of *nerve cells*, small masses containing nerve cells called *nerve centers*, or *ganglia*, and conducting or connecting elements called *nerve fibers*, bundles of which are termed *nerves*. These forms collectively constitute the complex apparatus known as the nervous system, frequently spoken of as the "ruler of the body."

For purposes of study and description in this book, the nervous system will be considered as divided into three parts, the *cerebrospinal* or *central nervous system*, the *peripheral nervous system*, and the *sympathetic nervous system*. Also, for ease in study and description, the impulses carried by the afferent or sensory nerves will be termed *impressions* while those carried by the efferent or motor nerves will be termed *impulses*.

The **central nervous system** consists of the *brain*, or *encephalon*, contained within the cranial cavity, and the *spinal cord*, or *medulla spinalis*, which occupies the upper two-thirds of the spinal canal. Together the brain and the spinal cord dominate the entire nervous system.

The **peripheral nervous system** consists of 12 pairs of *cranial nerves* attached to the brain and 31 pairs of *spinal nerves* attached to the spinal cord.

These nerves are associated with the functions of the special and general senses and with the voluntary movements of the body.

The **sympathetic nervous system** is often considered as part of the peripheral nervous system with which it is intimately connected and closely intermingled. It is also known as the *autonomic*, *vegetative*, and *ganglionic* nervous system.

Nerve tissue is made up of *nerve cells*, or *neurones*, and their processes, held together, in the brain and spinal cord, by a special supporting tissue called the *neuroglia* and by ingrowths of the membrane covering the brain and spinal cord, the *pia mater*. The **nerve cell**, or *neurone*, is the unit of structure and of function in the nervous system, varies in size, shape, and structure, and consists of the cell-body, or *cyton*, and one or more processes extending out from the body. Nerve cells having but one process are called unipolar cells, those having more than one, multipolar cells. The cell body, made of nucleated protoplasm, is the seat of origin of the changes which give rise to nervous impulses, and presides over the nutrition of the cell. The **processes** of nerve cells are outgrowths of the cell-body and provide the paths along which nervous impulses are carried. They are of two kinds, the *axone*, or *axis-cylinder process*, a single, unbranched process which lengthens out to become the axis cylinder, or conducting part, of a nerve, and the *dendrone*, *dendrite*, or *protoplasmic process*, a short process that divides into smaller and smaller branches which terminate in free ends that become lost in the nervous tissue (fig. 39). The axones vary in length, some extending only a very short distance beyond the cell while others continue to distant parts of the body. The longer processes, which usually acquire protective sheaths, are known as *nerve fibers*, and these, arranged in bundles, form the *nerves*, or *nerve trunks*, that pass to every part of the body.

FIGURE 39.—Motor nerve cell. (Howell.) *is the axone; the other branches are dendrites.

Nerve fibers are the conducting elements of the nervous system and bring the nerve cells into relation with each other and with the various tissues of the body. They constitute the greater part of the brain and the spinal cord, make up the nerves, and are known as *medullated* or *white fibers* and *nonmedullated* or *gray fibers*, the difference being due to the presence or absence of the white medullary sheath. The central and essential part of a nerve fiber is the *axis cylinder* which, in medullated fibers, is surrounded by the *medullary sheath* or *white substance of Schwamm*, and the whole enclosed in a delicate membrane called the *primitive sheath* or *neurolemma*, and in nonmedullated fibers is surrounded by a delicate nucleated sheath corresponding with the neurolemma of the medullated fibers. Medullated nerve fibers form the white part of the brain and the spinal cord and the greater part of every cranial and spinal nerve; nonmedullated fibers compose most of the sympathetic nervous system and some of the central. The medullated fibers constitute the *white matter* of the nervous system; the nonmedullated fibers the *gray matter*.

Nerves usually are classed according to the impressions or impulses they conduct and the direction in which the impression or impulse is carried. **Afferent nerves** conduct impressions of pain, hunger, feeling, etc., from all parts of the body into the central nervous system, and as these impressions are spoken of as sensations, afferent nerves are also known as *sensory nerves*.

Efferent nerves conduct impulses from the brain and spinal cord to the parts to which nerves are distributed. Most efferent nerves go to muscles and are commonly termed *motor nerves;* those that go to secreting glands are called *secretory nerves;* while those that restrain or check movement or secretion are called *inhibitory nerves.* Some nerves have both afferent and efferent fibers and are known as *mixed nerves.*

The cerebrospinal nervous system.

The **brain**, the largest and most complex mass of nervous tissue in the body, weighs about 3 pounds and fills the cranial cavity of the skull (fig. 40). It is continuous with the spinal cord at the *foramen magnum,* is very vascular, and when observed in life is seen to pulsate. The outer layer of the brain, the *cortex cerebri,* is made up of *gray matter* and the deeper parts of *white matter.* The gray matter, composed largely of nerve cells, receives and stores afferent impressions and transforms them into efferent impulses; the white matter, consisting principally of nerve fibers, conducts the efferent impulses. The brain is covered by three membranous coats, the *meninges,* which, named from without inward, are the *dura mater,* the *arachnoid,* and the *pia mater.*

The **dura mater,** a dense membrane of fibrous connective tissue, contains many blood vessels and is arranged in two layers, except in a few places. The outer layer of the dura mater is adherent to the inside surfaces of the bones of the skull where it forms their periosteum. The inner layer covers the brain and sends numerous prolongations inward for the support and protection of the lobes of the brain. These projections form the venous sinuses through which the blood is returned from the brain to the large veins of the neck. They also form the sheath for the nerves leaving the cranial cavity. The inner layer continues through the foramen magnum into the spinal canal to there invest the spinal cord.

The **arachnoid,** a delicate serous membrane, lies between the dura mater and the pia mater. Except in the longitudinal fissure of the brain this membrane does not dip down into the crevices and depressions of the brain. Between the arachnoid and the pia mater is a space called the *subarachnoid space,* in which is found a certain amount of cerebro-spinal fluid. It also continues into the spinal canal.

The **pia mater,** a delicate membrane of connective tissue containing a network of blood and lymph vessels, lies under the arachnoid and extends to all crevices and depressions of the brain. It contains the blood vessels of the brain and supplies blood to all parts of the brain. It frequently is called the nutritive membrane, and continues into the spinal canal.

The **brain** itself is divided into three main parts: The *forebrain,* containing the cerebral hemispheres and other bodies; the *midbrain,* a short constricted portion connecting the pons and cerebellum with the forebrain; and the *hindbrain,* consisting of the medulla oblongata, pons, and cerebellum (fig. 40).

The **cerebrum,** the largest part of the brain, fills the whole of the upper part of the cavity of the skull. It is composed of gray matter externally, which is the active part of the brain, and white matter internally, in which are embedded masses of gray matter. The outer portion of the cerebrum is made up of alternate elevations, called *convolutions,* and depressions, called *fissures.* The fissures divide the cerebrum into hemispheres and the hemispheres into lobes, the latter bearing names corresponding to the cranial bones near which they lie. The hemispheres are known as right and left.

The *great longitudinal fissure* extends from the front to the back of the cerebrum and completely divides it into two hemispheres except in the middle

portion where a broad transverse band of white fibers called the *corpus callosum* connects the hemispheres. The *transverse fissure* separates the cerebrum from the cerebellum. The fissures of the brain divide each hemisphere into sections called lobes, designated as the *frontal, parietal, temporal, occipital,* and *central,* or Island of Reil. Among the important fissures are the fissure of Rolando, called the *central sulcus,* running from the top and near the middle of each hemisphere downward and forward for two-thirds of its vertical measurement and separating the frontal lobe from the parietal lobe; the *lateral cerebral fissure* (Fissure of Sylvius), separating the frontal and parietal lobes from the temporal lobe; and the *parieto-occipital* fissure separating the parietal from the occipital lobe.

The function of the cerebrum is to govern all of the mental activities and coordinate body movements. This section of the brain contains the centers or seats of reason, intelligence, will, memory, and all of the higher emotions and feelings. Certain areas of the brain have a preponderance of control over certain functions, although all areas are more or less closely connected by *association fibers;* the frontal lobe is primarily the seat of reasoning or higher psychical thought; that portion just anterior to the central fissure is the motor area; the temporal lobe is the seat of hearing; and the occipital lobe is the seat of vision.

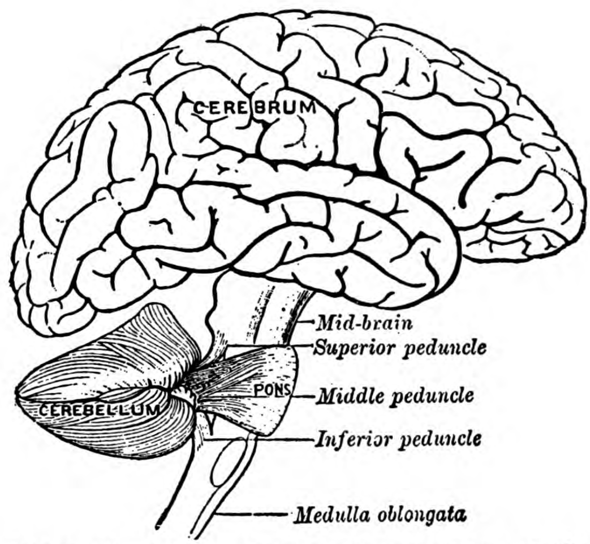


FIGURE 40.—Schema showing the connection of the several parts of the brain. (Gray.)

The white matter consists of fibers which run in three directions, from above downward, from the front backward, and from side to side. They form a connection between the different parts of the brain and connect the brain with the spinal cord.

Within the brain there are four communicating cavities called *ventricles.* These are the two *lateral ventricles,* one situated within each cerebral hemisphere, the *third ventricle,* lying in the lower middle portion of the brain and communicating on each side with a lateral ventricle, and the *fourth ventricle,* situated between the pons and the cerebellum, connecting above with the third ventricle and continuous through the medulla with the minute central canal of the spinal cord. The ventricles contain a clear lymph-like fluid, the cerebrospinal fluid. There are openings between the fourth ventricle and the space between the inner and middle layers of the meninges of the brain, which space is continuous with a similar space between the meninges of the spinal cord that also contains cerebrospinal fluid.

The cerebellum, sometimes called the "little brain," lies in the lower posterior part of the skull, between the occipital lobes of the cerebrum above, and behind the pons and medulla oblongata, with all of which it is connected. It is somewhat oval in form and consists of two lateral hemispheres and a central por-

tion called the *vermis*, or *worm*, and sometimes the *middle lobe*. A large, deep fissure called the *horizontal fissure* incompletely divides the cerebellum into an upper and a lower portion. Other deep fissures separate the hemispheres into lobes, and numerous, curved fissures, varying in depth and roughly parallel with each other, separate the lobes into layers, or leaves, the edges of which appear as fine ridges. The surface of the cerebellum therefore presents a slightly ridged and laminated, or leaf-like, appearance, instead of a convoluted one like that of the cerebrum. The substance of the cerebellum is composed of a solid, compact mass of white matter in the interior over which is a layer of gray matter, and its principal function is believed to be the regulation and coordination of ordinary movements and the maintenance of equilibrium.

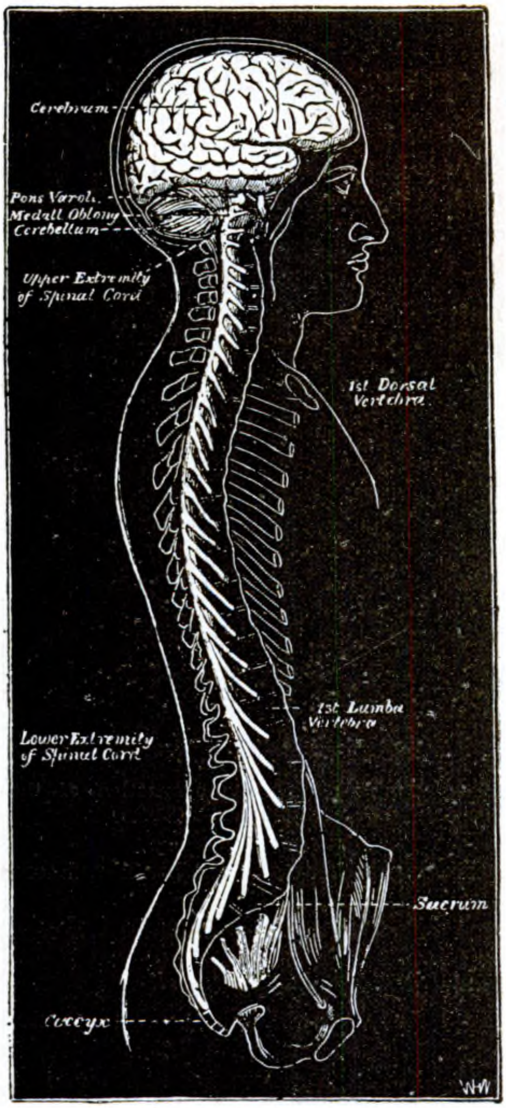


FIGURE 41.—Spinal cord and nerves. (Mason.)

The **pons**, or *pons Varolii*, is a roughly rounded, white mass situated in the midline of the cranial cavity at the base of the brain, in front of the cerebellum, beneath the cerebrum, and continuous with the medulla oblongata below. It is composed of a ventral, or anterior portion and a dorsal portion, and consists chiefly of rope-like bundles of nerve fibers connecting with the midbrain above and the medulla oblongata below, and areas of gray matter. From its surfaces emerge the narrow white bands of nerve fibers that connect the medulla oblongata with the cerebrum and the cerebellum, the pons thus acting as the "bridge" which its name signifies. In the gray matter of the pons are located the nuclei from which arise some of the cranial nerves.

The **medulla oblongata**, or *spinal bulb*, extends in an almost vertical direction from the lower margin of the pons, above, through the foramen magnum to the level of the upper border of the first cervical vertebra, or atlas, below, where it is continuous with the spinal cord. Shaped somewhat like a flattened pyramid or cone, it rests in and is supported by a shallow groove in the basilar portion of the occipital bone. It is divided into two lateral halves by two fissures continued into it from the spinal cord, the anterior one extending the entire length of the medulla and ending at the upper end, the posterior one ending in the lower half. The lateral halves are further divided longitudinally by grooves, and the surface of the medulla consequently appears convoluted. The

upper portion of the posterior surface forms the lower part of the floor of the fourth ventricle of the brain, and the minute central canal of the spinal cord passes through the lower half of the medulla and there opens out into the lower, tapered end of the fourth ventricle. The medulla is made up largely of a continuation of bundles of nerve fibers from the spinal cord, some of which end in the medulla while others pass on into the cerebellum. Much gray matter also is present in which are located numerous nerve nuclei and the reflex centers for regulating respiration, accelerating heart action, and maintaining vascular tone. In the lower part of the medulla a large part of the nerve fibers *decussate* (cross to the opposite side) which is the reason why one side of the brain controls nervous activity in the opposite side of the body. The functions of the medulla are largely conduction, reflex action, and automatic action, its function of conduction being especially important as it conducts all impressions passing between the brain and the spinal cord.

The **spinal cord**, or *medulla spinalis*, is that part of the central nervous system which occupies the upper two-thirds of the vertebral or spinal canal (fig. 41). It is nearly cylindrical in shape, being slightly flattened in front and behind, and extends from the level of the upper border of the atlas to the level of the lower border of the first lumbar vertebra, a distance of about 18 inches in the male. Above it is continuous with the medulla oblongata and below it ends in a cone-shaped extremity, the *conus medullaris*, from the point of which a slender filament, consisting mainly of fibrous tissue and called the *filum terminale*, extends downward about 8 inches where it is attached to the periosteum of the coccyx and so anchors the spinal cord. The nerve roots which spring from the lumbar and sacral portions of the spinal cord descend for a considerable distance in the spinal canal as a bunch of long nerve fibers which, from its resemblance to a horse's tail, is called the *cauda equina*. The three coats or membranes which cover the brain extend down and cover the spinal cord, and the subarachnoid space between the arachnoid and pia mater is likewise continued and also the cerebro-spinal fluid. Between the dura mater and the vertebral column is a protective covering of fatty tissue which also serves as a protection to the spinal cord. Two fissures, the *ventro-median fissure* anteriorly and the *dorso-median groove* posteriorly, almost completely divide the spinal cord, leaving only a narrow bridge of substance connecting the two halves. The bridge is called the *isthmus of the spinal cord* and in it is contained the minute cavity called the *central canal* which traverses the entire cord and communicates with the fourth ventricle of the brain. The spinal cord is made up of white matter surrounding an H-shaped section of gray matter (fig. 42). The anterior parts or horns of this H-shaped substance are short and bulky while the posterior ones are long and slender. The white matter is composed of bundles of nerve fibers running lengthwise of the cord, the gray of cell bodies, dendrones, axones, and collateral branches held together by neuroglia. The function of the bundles of nerve fibers is to conduct sensory impressions to and motor impulses from the brain.

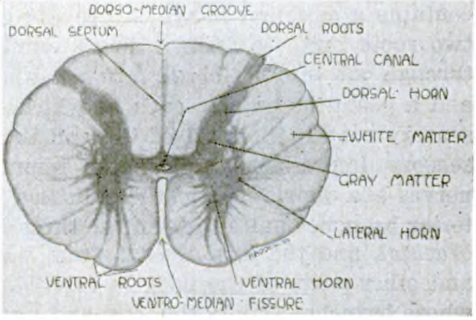


FIGURE 42.—Cross section of spinal cord at seventh thoracic vertebra. (U. S. Naval Medical School.)

The peripheral nervous system.

The **cerebral** or **cranial nerves**, consisting of 12 pairs, originate in the brain and supply certain definite areas of the body. They are of three varieties, sensory, motor, and mixed nerves which contain both sensory and motor nerve fibers. These cranial nerves after leaving the cranium through definite anatomical exits split up into branches and are widely distributed. They are numbered from before backward in the order in which they arise from the brain, and are named in accordance with their nature, function, or distribution.

NUMBER, NAME, TYPE, DISTRIBUTION, AND FUNCTION OF THE CRANIAL NERVES

Nerve No.	Nerve name	Type	Distribution	Function
1	Olfactory	Sensory	Upper third of the nasal cavity	Sense of smell.
2	Optic	do	Retina of eye	Sight.
3	Oculomotor	Motor	All eye muscles except superior oblique and external rectus.	Movements of eye.
4	Trochlear	do	Superior oblique muscle of eye	Do.
5	Trigeminal	Mixed	Skin of face, eyeball, lacrimal glands, mucous lining of mouth and pharynx, teeth, and tongue, muscles of mastication.	Taste, mastication, secretion, and touch.
6	Abducens	Motor	External rectus muscle of eye	Movements of eye.
7	Facial	do	All muscles of expression of face; also supplies ear and part of neck.	Facial expression.
8	Acoustic	Sensory	Internal ear	Hearing and equilibrium.
9	Glossopharyngeal	Mixed	Tongue and pharynx	Taste, movement of pharyngeal muscles and sensation to mucous membrane of pharynx.
10	Vagus	do	Larynx, trachea, lungs, heart, pharynx, œsophagus, and stomach.	Both motor and sensory to lungs and larynx. Cardio-inhibitory. Motor to œsophagus and stomach.
11	Accessory	Motor	Certain neck muscles	Movements of head.
12	Hypoglossal	do	Tongue	Movements of tongue.

The **spinal nerves**, 31 pairs in number, are named in accordance with the location of their exit from the spinal canal, there being 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal (fig. 41). Each nerve arises from the spinal cord by two roots, an anterior *motor root* and a posterior *sensory root* which contains a ganglion in which are the cell bodies of the sensory neurone. The two roots unite to form a single trunk which emerges from the spinal canal through an *intervertebral foramen* and immediately divides into an anterior and a posterior branch, each of which contains fibers from both the motor and sensory roots. Thus all of the spinal nerves are mixed nerves, for they carry sensory impressions and motor impulses. The posterior branches of these nerves are distributed to the skin and muscles of the back and trunk; the anterior branches unite to form the three great *plexuses* known as the *cervical*, the *brachial*, and the *lumbosacral*, from which the nerve supply to the extremities and other parts of the body is derived. From the cervical plexus arise nerves whose branches supply the skin and muscles of the head, face, neck, upper back parts of the shoulders, and thorax, and certain organs within the thoracic cavity; from the brachial plexus arise nerves that supply the upper extremity among which are the *median*, *ulnar*, and *radial nerves;* and from the lumbosacral plexus arise nerves that supply the lower extremities, the chief ones being the *sciatic* (the largest nerve in the body), the *femoral*, and the *obturator nerves*.

The sympathetic nervous system.

This system, also called the autonomic and vegetative, innervates all the involuntary muscles and the various glands of the body, the striated muscles of the heart, and the skeletal muscles may receive some sympathetic fibers. It consists of two rows of central ganglia situated one on each side of the median line, partly in front and partly at the sides, of the vertebral column and extending from the base of the skull to the coccyx, other ganglia situated in different parts of the body, and a network of small nerve trunks connecting the ganglia and ramifying to various organs. The central ganglia are joined with each other by cords of nerve fibers and each ganglion is connected with the spinal nerve of that region and with the spinal cord. A group or collection of ganglia and nerves supplying organs and structures in the body with nerve influence is called a *plexus*. Among the many of this system in the body are the *cardiac plexus* supplying the heart, the *epigastric* or *solar plexus* supplying the stomach, the *pulmonary plexus*, supplying the lungs, and the *hypogastric plexus* supplying the organs in that region of the body. Through the sympathetic system the movements of the viscera are regulated, the caliber of the blood vessels determined, the phenomena of secretion controlled, and the metabolic processes of life maintained. The activity of this system does not excite the consciousness and is almost entirely involuntary.

Nerve action.

The outstanding physiological property of nerve fiber is its *conductivity*, by which is meant the capacity of the nerve fiber to conduct impulses. For ease in description and study the impulses carried by the afferent nerves have been termed impressions throughout this section, while those carried by the efferent nerves have been termed impulses. A nerve *impression* may then be said to be the influence or effect on feeling, sense, or consciousness resulting from stimulation or excitation, and a nerve *impulse* the influence or effect on muscular or other tissue that incites it to action. Under normal conditions afferent nerve fibers are stimulated or excited only at their endings, called *receptors*, in the skin, mucous membranes, sense organs, etc., while efferent nerve fibers are stimulated only through the nerve cells from which they spring. Sensory impressions are converted into motor impulses in the nerve cells or nerve centers and the conversion may be totally unconscious as well as involuntary, as the emptying of the gall-bladder during digestion, or there may be consciousness of the act, as the winking of the eyelid when the eye is touched. On reaching the central nervous system sensory impressions may be carried to the brain, there to give rise to a specific sensation in the consciousness, or they may be conducted by a direct or a devious path within the central nervous system to a nerve cell or nerve center which converts them into motor impulses and conducts them away to incite response in some distant muscle or gland cell. When such a response occurs without intervening consciousness it is called *reflex action*, the nervous activity involved a *reflex*, and the path over which the impression and impulse travelled a *reflex arc*. The reflex is the basis of all functional activity of the nervous system, and the nervous function necessary for the control of the most intricate movements and activities is probably only a compounding of reflexes. In reflex action it is essential that there be: 1. A receptor on which the stimulant or excitant is brought to bear; 2. A path to the central nervous system by which the sensory impression is carried; and 3. A path from the central nervous system by which the motor impulse is carried. Although

the sensory impressions may be sent to and the motor impulse received from the brain in reflex action, it is believed that in most cases the impressions are received in the spinal cord and the motor impulses originated therein.

Thus, in response to impressions received over the afferent or sensory nerves, the nerve cells in the spinal cord send out orders without waiting for the impression to be carried to the brain or central nervous system and the orders sent out from there. As an example, the hand is pricked by a tack (fig. 43). The receptor nerve ending receives the sensation and the afferent or sensory nerves carry it to the spinal cord and brain. Before the sensation has reached the brain, however, an order to lift the hand has been originated by the nerve cells in the cord and sent out by the efferent or motor nerves. The hand is moved and the brain made conscious of the prick at about the same time.

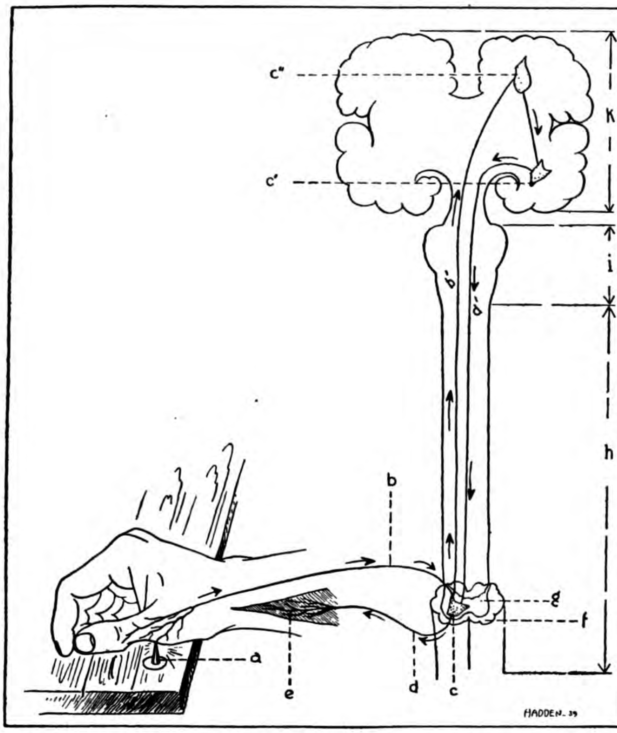


FIGURE 43.—Diagram of reflex action: *a*, Tack pricking hand; *b*, *b'*, afferent nerves; *c*, *c'*, *c''*, nerve cells; *d*, *d'*, efferent nerves; *e*, muscle moving hand; *f*, white matter; *g*, gray matter; *h*, spinal cord; *i*, medulla oblongata; *k*, brain.

Reflexes are classed as *simple reflexes*, in which a single muscle or gland is involved, as in the corneal reflex; *complex reflexes* in which several muscles or glands are involved, the action remaining perfectly coordinated, as in the patellar reflexes; *spreading reflexes* in which a large number of muscles are involved; *tonic reflexes* or continuous reflexes in which a reaction is repeated a number of times as in swallowing, coughing, hiccoughing, etc.; and *association* or *perception reflexes* in which a mental picture produces reaction, as in the flow of saliva or gastric juice when well-cooked food is seen or smelled, or when one person yawning causes others to do likewise.

The special senses.

Various kinds of external stimuli produce nerve impressions which give rise to the phenomenon in consciousness known as *sensation*. Stimuli within the body give rise to such sensations as *thirst*, *hunger*, *fatigue*, and many other less well-defined sensations. The body is equipped with various mechanisms especially adapted to receive specific forms of stimuli from external surroundings. These mechanisms are called the *organs of the special senses*. The skin contains various forms of sensory nerve endings, which, when acted upon by specific stimuli, give rise through the nerve impulses generated to such sensations as *heat*, *cold*, *pressure*, and *pain*. Other more elaborate mechanisms similarly provide for the senses of *sight*, *hearing*, *smell*, and *taste*.

The visual apparatus consists of the *eyeballs*, the *optic nerves*, and the *visual centers* in the brain, together with certain associated organs, as the *eyelids, eyebrows, muscles of the eyeball*, and the *lacrimal apparatus.*

The eyelids are two thin movable folds projecting from above and below, placed in front of the eye. They are covered externally by skin, and internally by a mucous membrane, the *conjunctiva.* This internal lining, the conjunctiva, is reflected over the front of the eyeball. The interior of the eyelid is composed chiefly of connective tissue, part of which is dense fibrous tissue which forms the *tarsal cartilage.* Several small glands, the *Meibomian glands*, are situated in this connective tissue. The upper eyelid contains a small muscle which acts to elevate or lower it. On the margin of each lid are double or triple rows of short hairs or cilia called the *eyelashes.* The function of the eyelids is to afford protection to the eyes. They are movable shades which may exclude light, dust, and other injurious substances.

The lacrimal apparatus consists of the *lacrimal glands*, the *canaliculi*, the *lacrimal sac*, and the *nasal duct.* The lacrimal gland is situated at the upper and outer angle of the orbit and secretes tears which flow to the surface of the conjunctiva via several small ducts. This secretion passes over the eyeball and is collected by the canaliculi at the inner angle of the conjunctiva. These canaliculi communicate with the lacrimal sac from which the tears are discharged into the nose through the nasal ducts.

The orbits are bony cavities in which the eyeball and its muscles are contained. They are shaped like a four-sided pyramid and are made up of seven bones, the *zygomatic, maxilla, palate, ethmoid, frontal, sphenoid*, and *lacrimal.* The orbit contains two openings posteriorly, the *optic foramen* for the passage of the optic nerve and the ophthalmic artery; and the *sphenoidal fissure* for passage of the ophthalmic veins and of nerves to the muscles of the eye.

There are six extrinsic muscles of the eye the function of which is to move the eyeball. These are the *internal, external, superior*, and *inferior recti* muscles, and the *inferior* and *superior oblique* muscles (fig. 44). The innervation of these muscles has been given under the cranial nerves.

The general shape of the **eyeball** is spherical, or, more exactly, it "is composed of the segments of two spheres of different sizes, the anterior being the segment of a small sphere forming about one-

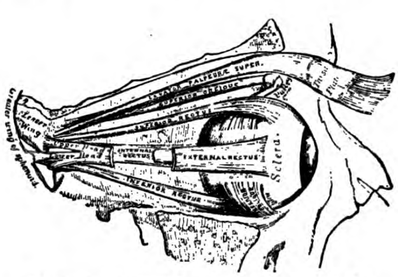


FIGURE 44.—Muscles of the right orbit. (Gray.)

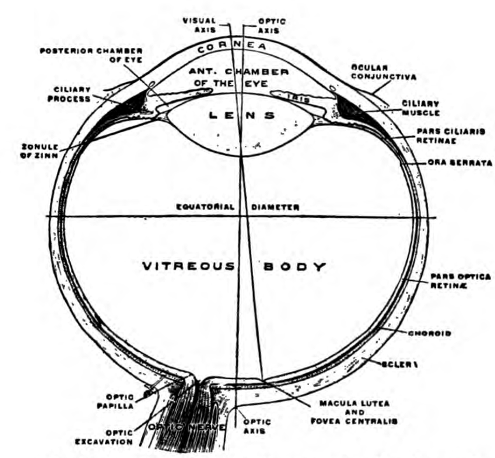


FIGURE 45.—The right eye in horizontal section. (Toldt.)

sixth of the eyeball and the posterior being the segment of a much larger sphere and forming about five-sixths of the globe" (fig. 45). The surface of the eyeball is made up of three distinct coats or layers. The outer layer consists of the sclera and the cornea. The **sclera** or "the white of the eye" is a dense, tough, fibrous

membrane covering the posterior five-sixths of the eyeball and pierced posteriorly by the optic nerve. In front where the light enters the eye the sclera changes to a transparent membrane having no blood vessels, which covers the remaining sixth of the eyeball and is known as the **cornea.**

The middle layer is composed of the choroid and the iris. The **choroid** is a thin, vascular, chocolate-colored membrane lining the sclera and containing a network of blood vessels and pierced in the back by the optic nerve. It is folded inward and arranged in radiating folds about the lens of the eye. These folds form the *ciliary processes* and are well supplied with nerves and blood vessels and the *ciliary muscle* is contained therein. The **iris** is a thin, circular, contractile disc directly back of the cornea and suspended in front of the lens but not in contact with it, and perforated near its center by a circular opening called the *pupil.* It divides the space between the cornea and the lens into *anterior* and *posterior chambers* which contain a watery substance called the *aqueous humor.* The iris is composed of connective tissue, pigment cells, blood vessels, and contains two sets of muscles. One set of muscle fibers contracts the pupil, the other dilates it. The function of the iris is to regulate the amount of light entering the eye—by contracting, it decreases the amount of light entering, by dilating, it increases it. This is the part that gives the eye its characteristic color.

The inner layer of the eye is the **retina,** which is essentially the expanded fibers of the optic nerve. It is the screen on which the images fall, is most essential to vision, and is a transparent, purplish-colored membrane situated between the inner surface of the choroid and the outer surface of the *vitreous body,* a transparent jelly-like substance nearly filling the cavity of the eyeball and separated from the retina by the *hyaloid membrane.* The retina consists of eight layers of cells, the most important of which is the first or external layer, called the "layer of rods and cones," in which the cells act as end organs to the optic nerve.

The **crystalline lens** is a solid transparent body enclosed in a transparent capsule or membrane and held in place by a ligament. It is situated between the iris in front and the vitreous body behind. The lens is an elastic body which hardens and loses its elasticity with age. It is kept normally tense by the pull of the suspensory ligament on the capsule. When the eye is adjusted for near vision, the ciliary muscle contracts, drawing the choroid forward, relaxing the suspensory ligament and allowing the lens to change its shape. This is called *accommodation.*

Common defects of accommodation are:

1. *Hypermetropia,* or farsightedness, a condition in which the focal point for near objects is behind the retina.
2. *Myopia,* or nearsightedness, a condition in which the rays are brought to a focal point before the retina is reached.
3. *Presbyopia,* a condition similar to hypermetropia, found in old age and due to loss of elasticity of the lens.
4. *Astigmatism,* a condition in which the curvature of the cornea or lens is defective, causing a dispersion of rays and a blurring of the image.

The **ear** or the *organ of hearing* is composed of three parts: The *external,* the *middle,* and the *internal ear* (Fig.46). The **external ear** consists of the *auricle* and the *external auditory canal,* which extends from the outside to the *eardrum,* or *tympanic membrane.* This membrane separates the external from the middle ear. The **middle ear** (tympanic cavity) is a small, irregular, air-filled cavity located in the temporal bone. It communicates with the pharynx, by the Eustachian or auditory tube, and also with the mastoid air cells, and

is separated from the internal ear by a thin bony plate containing two small openings, one of which is closed by a thin membrane. The other opening, the *fenestra ovalis*, is the connection between the middle and the internal ear, and is occupied by the base of the stapes, one of the *ear ossicles* or bones located within the middle ear. These bones form a chain extending from the tympanic membrane to the fenestra ovalis. The **internal ear** contains the perceptive organ of hearing and consists of a *bony labyrinth* hollowed out of the petrous portion of the temporal bone. This labyrinth is lined with a membrane, contains a fluid called *endolymph*, and is divided into the *vestibule*, the *semicircular canals*, and the *cochlea*. The semicircular canals and vestibule receive nerve endings from the vestibular branch of the auditory nerve and have to do with the sensation of equilibrium.

FIGURE 46.—Section through right, external, middle, and internal ear. (Howell.)

The end organs of hearing are located in the cochlea. Hearing is accomplished by sound waves which strike against the eardrum and are transmitted by the ear ossicles to the endolymph of the internal ear, the movement of which stimulates the end organs of hearing. The center of hearing is in the temporal lobes of the brain.

The **sense of smell** is accomplished by emanations from certain substances coming in contact with special nerve endings of the olfactory nerve which are distributed to the mucous membrane of the upper part of the nasal chambers.

Taste is accomplished by certain end organs known as *taste buds*, which are groups of modified epithelium cells of the tongue around which terminate nerve fibers. The perceptive portions of the tongue are the tip, the borders and the posterior portion of the dorsum. The nerves concerned with the sense of taste are the *chorda tympani* branch of the facial, the *lingual* branch of the trigeminal, and the *glossopharyngeal*. There are four fundamental tastes: *salt*, *sweet*, *acid*, and *bitter*. The pleasing variations which commonly are called taste are usually combinations of taste and smell. It is necessary for a substance to be in solution to stimulate the nerve endings concerned with taste.

Certain special functions and activities.

Speech, or the *expression of coherent thought* is brought about by a combination of several acts under control of a certain brain center. The center of speech is considered to be located deep in the left temporal lobe of the brain. The larynx contains folds of mucous membrane called *vocal chords*, which are controlled by muscles which separate or bring these folds together according to the pitch of tone desired. When air is forced from the lungs past these folds certain sounds are produced, and in conjunction with the movements of the pharynx, tongue, lips, and cheeks articulate speech results.

Sleep is a period of more or less unconsciousness, during which most of the higher psychical powers are quiescent, but during which the physiological activities continue. It usually is considered a period of rest, in which the *constructive processes* exceed the *disassimilitory* or *katabolic changes*. Certain changes take place during sleep; respiration is slowed, the pulse slowed, and less blood is sent to the brain and greater amounts to the extremities. The cause and necessity for definite periods of sleep is not thoroughly understood.

Heat regulation, or *maintenance of constant body temperature* is a two-sided process, and consists of controlling the loss of heat as well as the production of heat. Heat is lost through the excreta, through expired air, by

evaporation of sweat, and by radiation and conduction from the skin. Heat is produced by physiological oxidations within the body. This is effected by muscular exercises and partly by the variety and quantity of food.

The preservation or elimination of heat is controlled chiefly by the sympathetic nervous system, by nerves to sweat glands and vasomotor nerves. An increase of blood to the skin, increases the loss of heat by radiation. The opposite effect may be produced by vasoconstriction or decrease of blood to the skin.

Fever is an abnormal condition of increased temperature, the exact cause of which is unknown. Generally it is considered to be a metabolic disturbance caused by certain toxic substances which act upon a possible heat center in the brain and influence the sympathetic nervous system.

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CHAPTER III

Section 1.—MINOR SURGERY AND FIRST AID

Minor surgery is that part of surgery which includes procedures not endangering life. The application of bandages, splints, dressings and sutures, counterirritation, cauterization, and similar simple surgical measures are all considered as being within the scope of minor surgery.

First aid is the emergency treatment of the sick or injured before regular medical or surgical attention can be given. It should neither supersede nor take the place of proper medical or surgical attention and should consist of furnishing temporary assistance to a sufferer pending the arrival of medical aid. In rendering first aid there are certain things that are to be done in all cases of injury or illness. After taking charge of the situation the hospital corpsman should:

1. *Send* for a medical officer or somebody capable of giving the proper treatment.
2. *Have* somebody keep bystanders far enough away to give room to work without hindrance.
3. Lay the patient on a blanket, or clothing spread out flat, with the head level with the body; do not permit him to sit or stand up.
4. Loosen the patient's clothing about the neck, chest, and abdomen.
5. Examine the patient to determine the nature of the injury or illness, paying particular attention to evidence of hæmorrhage, stoppage of breathing, poisoning, wounds, fractures, dislocations, burns, etc. If necessary, cut or rip clothing to get it away from the injured part. In making the examination look at or feel of the chest to determine whether the patient is breathing, note the color of the face, especially the lips and cheeks, look for bleeding from the nose and ears, determine if he is conscious by asking questions of him, examine the lips and mouth for burns, discoloration, or bloody froth and the tongue for cuts, smell the breath for evidence of alcohol or poisons, and feel for the pulse to determine the character of the circulation.
6. Proceed with first-aid treatment at once, treating serious hæmorrhage first, stoppage of breathing next, and other conditions in the order of their seriousness. Remember to keep the patient warm.
7. Note the location of the accident or of the patient; inquire of the patient or bystanders as to what happened; get the time the accident or illness occurred and the names of the patient and witnesses; be prepared to receive an ante-mortem statement and be sure to have at least two others hear such statement, it may be the patient's noncupative or oral will.

A hospital corpsman giving first aid should do so with evident display of self-assurance and authority born of knowledge, with decision, calmness, alacrity, and alertness of mind, thereby obtaining the confidence of the patient and of interested bystanders.

INFLAMMATION

Inflammation may be described as the changes which occur in living tissue when it is injured, providing that the injury is not of such a degree as tends to destroy the structure and vitality of the patient. When tissue is injured, the following changes take place: Engorgement of the blood capillaries in the injured tissue and a seepage through the dilated capillary walls of blood fluids and blood cells, particularly white blood cells (phagocytes). Nature brings about these changes with the object in view of bringing aid of a reparative and a nutritive nature to the cells which make up the tissue injured. Inflammation manifests itself by certain local signs and symptoms which are produced by changes in the injured tissue. These symptoms are heat, pain, discoloration, swelling, and disordered function of the part involved. Heat and discoloration are due to the enlargement of the blood capillaries, the swelling to the throwing out of blood fluids and cells into the injured tissues, and the pain to the pressure of pent-up fluids on the nerve ends in the area affected. There may also be constitutional symptoms, as *increase of temperature* and *increase of white blood cells* (leucocytosis) which depend in a large measure upon the cause of the inflammation and the absorption into the general circulation of the broken-down products of this inflammation.

The causes of inflammation are: *Traumatic,* such as blows and mechanical irritation; *chemical,* such as stings of insects, mustard, venom of serpents, ivy poisoning, etc.; *thermal,* heat and cold; *microörganisms,* such as staphylococcus, streptococcus, etc.; and *agencies,* such as electricity, X-rays, actinic rays of the sun, etc.

The general principles involved in the **treatment** of inflammation are: 1. To remove the exciting cause; 2. To keep the inflamed part at rest; and 3. To reduce the local blood pressure by elevation of the part.

Other agencies employed in the treatment of inflammation are heat and cold, wet dressings, and ointments. Heat acts by softening the tissues and hastening the carrying away of the products of inflammation, thus decreasing the pressure on the nerve ends in the inflamed area. Cold acts by contracting the dilated blood capillaries and thus decreasing tension. Wet dressings and ointments act by softening the tissues and frequently contain some agent to rid the inflamed area of the specific cause of the inflammation—some microörganism, for instance.

The conditions in which inflammation plays a very important part are: Fractures, dislocations, sprains, strains, wounds, burns, frostbite, and many kinds of infection.

Inflammation due to microörganisms or bacteria differs from inflammation due to other causes in that the cause of septic inflammation, or inflammation due to bacteria, is a living organism which multiplies and throws off poisons in increasing quantities until such time as the white blood cells and blood fluids thrown out from the dilated capillaries can overpower it. In the case of aseptic inflammation the cause is other than bacterial.

The principal danger in a septic inflammation is that the white blood cells and blood fluids will not be able to overcome the microörganisms which may gain access to the circulation and set up areas of inflammation elsewhere in the body. The term applied in this condition is *sepsis.*

Bacteria which cause infection or sepsis are present in myriads on the surface of the body and on every article touched, unless it has been sterilized. The skin and mucous membranes protect from infection and sepsis, and it is only when there is a break in these tissues that the bacteria of sepsis gain entrance and start septic inflammation. All bacteria of infection and sepsis do not cause the same degree of inflammation, some causing mild and others very severe inflammation. In the case of some it is easy for blood fluids and white blood cells to limit the inflammation locally, while with others it is difficult for them to do so.

An abscess is a localized area of infective inflammation containing live and dead microörganisms, live and dead phagocytes (white blood cells which have been combating the microörganisms), fluids forced out from the blood capillaries, and the broken-down products of dead tissue cells. The content of an abscess is called *pus.*

The *treatment* of an abscess is in accordance with the rules for treating other inflammations, but with the added rule that the *pus when formed must be evacuated.* Abscesses should be incised and drainage instituted, in order to reduce pressure on the tissues, rid the tissues of the irritating products of infective inflammation, and lessen the chances of the infecting organism gaining access to the general circulation and causing further trouble. Strict care must be taken not to introduce further infective organisms when the incision is made; that is, an aseptic technique must be employed. The incision must be large enough to allow good drainage. Never squeeze an abscess as this tends to break down Nature's barrier and to spread the infection. Depending on the severity of the inflammation, more or less of this tissue may die, and this dead tissue is spoken of as *slough.* When the slough includes the skin or mucous membrane, an *ulcer* results.

A boil, or furuncle, is an abscess in the true skin in which the infecting microörganism generally gains access by way of a sebaceous or a sweat gland, and in which there is a small slough in or beneath the true skin. A boil at the end of the nose or within the nostrils is very dangerous because, as a result of handling, incision, or other trauma, the infection enters the blood and is very easily carried by veins to the large venous channels on each side of the sphenoid bone (the cavernous sinuses) and thence spreads to the brain to form abscesses, or to the meninges to cause meningitis, or into the general circulation to result in septicæmia and possibly death.

A carbuncle is a boil or furuncle, in which there are multiple sloughs often coalescing in one beneath the true skin. When the pus from these sloughs finds its way to the surface an opening occurs, hence the numerous foci of pointing (called "coming to a head"). Carbuncles, wherever they are located, are very dangerous, those about the face being especially so on account of the ease with which the infection can be carried to the cavernous sinuses and thence to other parts of the body as explained in the preceding paragraph. A patient suffering from one should be brought immediately under the care of a medical officer. If a furuncle breaks, one opening results; if a carbuncle breaks, numerous openings result. Diabetes, Bright's disease, and conditions of lowered resistance brought about by living in impure air, on improper foods, etc., render an individual particularly susceptible to boils.

Boils and carbuncles should be *treated* by first placing the site of the furuncle or carbuncle at rest, and putting the patient to bed is advisable. X-ray therapy is the ideal treatment when the boil or carbuncle is in the indurated state, that is, before it has "come to a head." If X-ray therapy is not available the treatment should be: 1. Rest and avoidance of trauma; 2. Applica-

tion of heat by hot wet-dressings; 3. Relief of pain (aspirin or codeine may be given); 4. Ample fluid intake and high-caloric diet; 5. When there is definite fluctuation make a small incision to evacuate the pus. When there is a medical officer present and in the absence of X-ray facilities, early, radical, and complete excision is curative. No attempt should ever be made to treat a boil at the end of the nose or within the nostrils as over or faulty treatment may result in death. The best treatment for boils in these areas, except that ordered by a medical officer, is to leave them strictly alone; they may be looked at but not touched or handled.

SHOCK

Shock is a sudden depression of the vital functions of the body. The nervous system, which controls these vital functions, may be likened to a system of electric wiring. If too heavy an electric current is made to traverse the wires in an electric system they are likely to be burned out, or fuses blown. Similarly, if too violent impulses traverse the nerve paths in the body, there may be death from complete nonfunctioning of the nervous system, or there may result a much milder condition in which there is only partial functioning of the same. As the nervous system controls all the vital functions, so in shock they are all more or less affected. Practically any impulse traversing the nerve paths, if severe enough, may cause shock. There is *emotional shock*, where the impulses originate in the brain; *traumatic shock*, which results from a severe blow in the solar plexus or testicle, or from crushing or cutting a large nerve trunk, or from some severe injury; and *electrical shock* resulting from a heavy electric current traversing the nerve paths.

One of the main effects of too violent impulses on the nerve track is the loss of nerve control over the blood vessels, resulting in the circulating blood collecting in the veins, especially the large veins of the abdomen and depriving the brain and other parts of the body of their normal supply. More or less shock occurs from all injuries. Depending upon the stability of the nervous systems of individuals, what might cause a mild case of shock in one could cause a severe case in another.

Symptoms.

A person suffering from severe shock lies in a drowsy condition, with the limbs limp, but generally is not totally unconscious. The skin is pale and cold; the temperature is subnormal; the pulse is feeble, fluttering, and rapid, and may be irregular and barely perceptible; the respirations are shallow and sighing; the pupils are generally dilated. Great thirst is frequently an accompaniment of shock.

The sensibility of these patients often is lowered and they do not feel pain as acutely as in a normal condition. Shock may result in immediate death from heart failure, or a condition known as *reaction* may be established. This state frequently is ushered in by vomiting and is characterized by a gradual return of color to the skin and a rise of body temperature accompanied by an improvement in the heart's action and fuller and deeper respirations. After reaction is established, it is not unusual for the patient to fall into a sound sleep. In a case of mild shock, there may be nothing more than momentary paleness, weakness, and perhaps some temporary confusion of the thought. Other names applied to conditions of shock are faintness and collapse.

Concealed hæmorrhage resembles shock very closely, and always must be kept in mind in all cases of severe shock.

Treatment.

The principle underlying the treatment of shock is to bring the blood which has accumulated in the large abdominal veins back into the general circulation, to bring the proper blood supply back to the brain where the vital centers are situated and to the surface of the body, and to administer proper stimulation. If the shock is at all severe, a medical officer should be summoned immediately, but treatment must be started at once without waiting for his arrival. This may be accomplished by placing the patient in the proper position, applying warmth and administering stimulants. The position in which the shocked person is to be placed is on the back with the head low in order that the blood will tend to run into the brain. A good way to do this is to raise the foot of the bed or bench on which lying. Never raise the head of a shocked person by placing it on a pillow. The application of warmth acts as a stimulant, and also tends to bring the blood to the surface of the body. Warmth should be applied both externally and internally. Externally, warmth is applied by friction and rubbing of legs and arms briskly toward the trunk, by putting the patient on a bed in a warm room, covering with blankets and surrounding with hot-water bags, hot bricks or stones. Care must be taken that the latter are properly covered and not so hot as to burn the patient. Loss of body heat always increases shock; therefore, never remove more clothing than necessary from a shocked person, and when possible spread blankets or coats over him. Be careful, while rubbing, that the patient is not uncovered. Warmth is applied internally by hot drinks such as coffee or hot beef tea in small amounts, given frequently, and hot enemas, such as 2 pints of hot saline solution. Care must be taken not to burn the patient. Stimulants used *by mouth* are one-half teaspoonful of aromatic spirit of ammonia in one-half glass of hot water, hot coffee, hot tea, hot beef tea, or plain hot water; *hypodermically*, one-thirtieth grain of strychnine, or caffeine and sodium benzoate, 2 to 5 grains; and by *inhalation*, smelling salts or ordinary water of ammonia. Unconscious persons or those unable to swallow should never be given any thing by mouth. The inhalation method is particularly useful in such cases. The most important treatment in electrical shock is artificial respiration which should be continued at least 4 hours in all cases. Shocked patients who have resumed breathing often later stop breathing, and they should be watched closely for hours after treatment.

It must be borne in mind in the treatment of all severe injuries that they are accompanied by more or less shock, and that the treatment of this shock is perhaps just as important as the treatment of the injury itself.

HÆMORRHAGE

Hæmorrhage or bleeding is the escape of blood from the heart or blood vessels due to a break in their walls. Hæmorrhage is spoken of as *arterial*, *venous*, and *capillary*, depending upon whether the escape of blood is from arteries, veins, or capillaries. In *arterial hæmorrhage* the blood is bright red in color, and escapes in jets; in *venous hæmorrhage* there is a rapid flow of dark blood, a welling up, as it were, without any spurting; and in *capillary hæmorrhage* there is a steady oozing of red blood from the entire wounded surface.

Nature's method of arresting hæmorrhage is by the clotting of blood, thus forming a plug at the point of bleeding. In the average healthy person, it takes from 3 to 5 minutes for blood to clot. There are, however, some abnormal people whose blood-clotting time is very much lengthened and the

arrest of hæmorrhage in them is very difficult. These people are spoken of as *hæmophiliacs* or *bleeders.* The clot of blood which arrests the hæmorrhage eventually organizes and permanently plugs the break in the vessel wall if it remains undisturbed. Certain factors favor and hasten the formation of a clot at the point of bleeding, such as the stopping or slowing of the blood stream at that point, and the obliteration or decrease in size of the opening in the blood vessel where the hæmorrhage is occurring. When an artery is cut or torn, the muscular wall contracts, thus decreasing the size of the opening. With the increase in loss of blood, the pressure within the circulatory system becomes lower and lower. When the hæmorrhage occurs in a confined space, the pressure of exuding blood in the surrounding tissue and on the blood-vessel wall tends to slow the current of blood and close the opening in the blood-vessel wall.

Treatment.

It is possible to assist Nature in arresting hæmorrhage by elevation of the bleeding part, thus decreasing the pressure of blood at the point of hæmorrhage with the help of gravity; by keeping the patient at complete rest so that the blood clot at the point of bleeding will not be disturbed and so that the blood pressure at that point will be as low as possible, due to the slow beating of the heart; by the application of heat or cold, which tends to cause the blood-vessel wall to contract; by the use, at the point of hæmorrhage, of styptics, medicinal substances which act to hasten blood clotting or cause contraction of blood-vessel walls; by the use of pressure to close the bleeding vessel; and by the use of ligation or torsion, also to close the bleeding vessel. *Do not give stimulants* in treatment of hæmorrhage, as they increase the blood pressure and tend to cause the dislodgment of the clot at the bleeding point.

Capillary hæmorrhage is treated by elevating the part and applying very hot or very cold water, followed by the application of uniform pressure by means of a gauze compress and bandage. In some cases it may be necessary to apply a styptic, such as epinephrine (adrenalin). Epistaxis, or nosebleed, and bleeding from a tooth socket after extraction of the tooth are examples of capillary hæmorrhage.

In **epistaxis,** or **nosebleed,** keep the patient quiet and in a sitting position; remove collar or any constriction about the neck; apply cold or ice to the back of the neck, and instruct the patient to breathe through his mouth and *not to blow his nose.* The cold application to the back of the neck causes a reflex contraction of the blood vessels of the nose. Styptics, such as a solution of alum or of epinephrine, may be snuffed up the nose. Put a roll of paper under the upper lip, between it and the gum. If bleeding still continues, the nostril must be packed by taking some soft material—cotton, linen, or lint—and gently forcing it well back into the nose. If bleeding continues, the person is probably a hæmophiliac, and a medical officer should be summoned. In severe bleeding from a tooth socket, pack the cavity tightly with cotton or linen saturated with some styptic, such as epinephrine or alum; then have the jaws closed tightly and apply a Barton or a four-tailed bandage.

In **venous hæmorrhage,** elevate the part (so little velocity is there in the venous current that often this procedure alone will stop the bleeding). If bleeding continues, make pressure directly over the wound with a sterile compress. If venous hæmorrhage is from an extremity, the limb should be bandaged from toes or fingers up to the bleeding point in addition to pressure over the point. A common location for severe venous hæmorrhage is from varicose veins of the legs.

In the treatment of **arterial hæmorrhage** prompt and decisive measures are required, particularly in the case of hæmorrhage from the large arteries.

Hæmorrhage from the femoral artery may result fatally in a few minutes. The main reliance must be on the more strenuous methods, viz., *pressure, ligation,* and *torsion.* Ligation is the tying off of an artery with sutures, and torsion consists in twisting the end of the vessel with forceps or an artery clamp for five or six rotations; these two methods should be left to a medical officer ordinarily and should not be undertaken by the first-aid man unless absolutely necessary. This leaves the pressure methods available as the main reliance of the first-aid man.

Pressure to control arterial hæmorrhage always must be applied at some point between the bleeding point and the heart, preferably at a point where the bleeding artery can be compressed against bone. Pressure may be applied by means of the fingers, spoken of as digital pressure, or by means of compresses or by the application of a tourniquet. *Digital pressure* can serve only for a short time, as the fingers soon become tired. This pressure should be made with the thumbs and should be firm enough to arrest the bleeding; it should be made over the clothes, as too much time may be lost in removing them. One will know that he is pressing on the right place by feeling the artery beating beneath the thumbs and by the arrest of the bleeding; if the artery cannot be found, make pressure directly over the bleeding point. As pressure with the thumb soon becomes tiresome, an assistant should relieve the first-aid man who should prepare to apply other pressure methods, either tourniquet or compress. A *tourniquet* is a constricting band, and there are various kinds. The principle of all tourniquets is a pad over the artery to bring the pressure on the artery and take it off the veins, a band around the limb and over the pad, and some means of tightening the band. There are a number of special tourniquets, but as they are not usually at hand, a suitable one must be improvised. An excellent one may be improvised with a rubber bandage, a number of turns being made about the limb and the rolled portion of the bandage then placed under the last turn in such a position as to press directly on the artery. The most common improvised tourniquet is the so-called Spanish windlass, in which arrangement any rounded, smooth, hard object, such as a stone, a cork, or a roller bandage, is used as a compress; for the band, a handkerchief, a suspender, a waistbelt, a bandage, or anything of the sort may be used. To tighten the band, a stick, bayonet, or scabbard, or something of the kind, is passed under the band and twisted until the bleeding ceases, and the ends are then tied to the limb to prevent the band from becoming untwisted. *Pressure by means of compresses* may be effected as follows: A number of small pieces of gauze or linen, or a tampon, previously rendered sterile or antiseptic, are placed in the wound, one on top of the other, until there are a sufficient number to compress the bleeding vessel; a bandage then is applied firmly to hold them in place and exert the necessary pressure. Sometimes more effective pressure can be obtained by employing a compress of gradually increasing size (cone-shaped with apex nearest the vessel). Compresses may be applied in the same manner along the course of the vessel.

The dangers in the use of tourniquets and constricting bands for the control of hæmorrhage are that if applied tight enough to stop arterial hæmorrhage they cause pain and swelling of the limb, and if left long enough may cause gangrene or death of the part below the constriction. Therefore they should be watched and loosened from time to time, at about half-hour intervals. If on loosening the tourniquet the bleeding starts again, tighten it up; if there is no appearance of bleeding leave the loose tourniquet in place with an attendant instructed to tighten it should the bleeding recur. The tourniquet method is the most effective in the majority of cases, but due to the attendant after-

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dangers, in all but the most severe hæmorrhages of the larger arteries arrest of the bleeding by elevation of the part and the compress method should be tried first. All possible care should be taken not to infect the tissue with dirty applications, but sometimes in tremendous hæmorrhages all these precautions have to be laid aside to save the person's life. In all cases of severe hæmorrhage the measures mentioned are only preliminary to arrival of a surgeon.

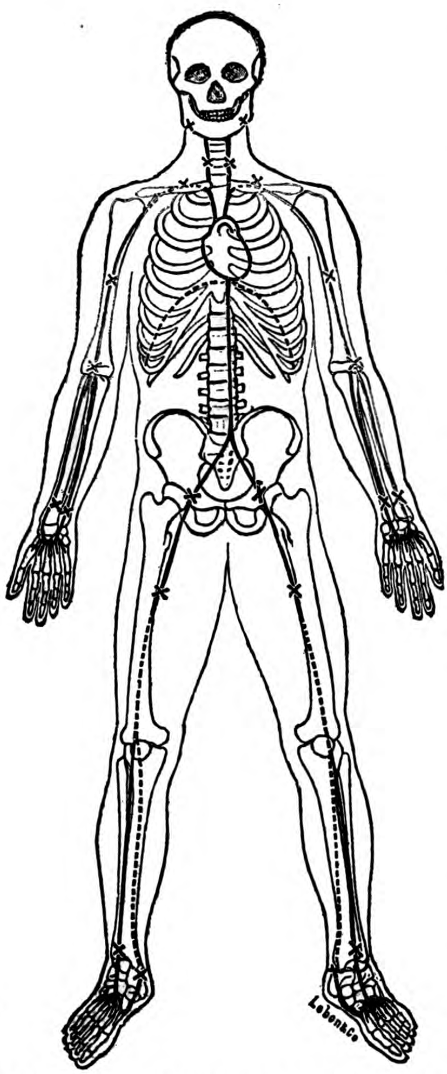

FIGURE 47.—Skeleton with black and dotted lines showing the course of the arteries and x indicating the pressure points. (Mason.)

With great loss of blood the patient suffers severe collapse and must be given treatment for shock, except that stimulants must not be given unless the blood vessel has been safely secured against recurrence of the hæmorrhage. After severe hæmorrhage tremendous thirst generally is complained of and should be relieved with frequent, small drinks. This may be termed the *constitutional treatment* of hæmorrhage.

The specific treatment for hæmorrhage from certain parts of the body is described immediately following:

Bleeding from the scalp.—Apply pressure over wound with compress and bandage.

Arterial bleeding from the lips.—Grasp lips between thumb and fingers on each side of wound, as the arteries to the lips come from both sides.

Arterial hæmorrhage in other parts of the face.—Apply digital pressure on the facial artery against the lower jaw midway between the ear and chin where its pulsation can be felt (fig. 47).

Arterial hæmorrhage from neck.—Apply digital pressure with the thumb on the carotid artery against the vertebræ. (A tourniquet cannot be used in this location.) (Fig. 47.)

Arterial hæmorrhage from the armpit.—Place a compress in the armpit and bind the arm tightly to the side. If this fails, compress the subclavian artery behind the clavicle (collar bone) between the thumb and first rib, or compress it with a key, the handle of which has been padded (fig. 47).

Arterial hæmorrhage of arm, forearm, or hand.—Apply digital pressure on the brachial artery on the inner side of the biceps, and then apply a tourniquet a little higher up. In case of arterial hæmorrhage of the forearm, a pad may be placed in the bend of the elbow and the forearm forcibly flexed on the arm. In case the hæmorrhage is from the palm, either of these two methods may be used, or a large firm compress may be placed in the hand with the fingers very tightly closed over it and bandaged in place (fig. 47).

Arterial hæmorrhage from the thigh, leg, or foot.—Compress the femoral artery against the head of the femur just below the middle of the groin with both thumbs, then apply a tourniquet to replace the thumbs. In case the hæmorrhage is in the leg or foot, another method is to put a pad behind the knee, flex the leg forcibly, and tie it in that position. With arterial hæmorrhage in the foot, in place of these two methods, compression can be made, when the bleeding point is on the dorsal surface, on the anterior tibial artery at the instep; and, when the bleeding is on the plantar surface, on the posterior tibial artery behind the internal malleolus (fig. 47).

Hæmoptysis is hæmorrhage from the lungs. It may result from wounds of the lung but more often is due to disease of these organs. The patient usually is seized by a fit of coughing and spits up bright red, frothy blood. Unfortunately, nothing can be done to arrest the hæmorrhage quickly. The treatment consists of immediately summoning a medical officer, and in the meantime keeping the patient absolutely quiet, at rest, and giving ice by mouth. Listen over the chest, and where rattling is heard, apply an ice bag. Avoid all stimulants.

Hæmorrhage from the stomach.—The vomited blood is usually dark in color and may be mixed with food. It always should be remembered that vomited blood does not necessarily indicate hæmorrhage from the stomach; blood coming from the back of the nose and throat may have been swallowed, and inquiry should be made to find out if there has been any nosebleed. The blood from pulmonary hæmorrhage contains air and is frothy while blood from the stomach is not. The treatment is the same as for hæmorrhage from the lungs, except that the ice bag is applied over the upper abdomen.

Internal hæmorrhage, also called concealed hæmorrhage, may occur in any of the cavities and from any of the organs of the body as the result of injuries or disease. It is a condition which may be very difficult to diagnose, as the bleeding cannot be seen. Frequently the only symptoms are those of shock. In such cases summon a medical officer immediately; in the meantime, place the patient flat on his back and keep him absolutely quiet. Opiates are indicated in hæmorrhage of this nature, their purpose being to produce quietness.

Primary hæmorrhage occurs immediately on receipt of a wound or injury. After the arrest of primary hæmorrhage, a recurrence may occur, caused by dislodgement of the clot, the slipping of a ligature, or from the opening of a blood vessel by separation of a slough. Recurrence of hæmorrhage within 24 hours is spoken of as **consecutive** or **intermediate,** and recurrence after that time is spoken of as **secondary hæmorrhage.**

WOUNDS

A **wound** is defined as the forcible solution of continuity of any of the tissues of the body. The principal kinds of wounds are: *Clean* or *aseptic wounds; infected* or *septic* wounds; and *poisoned wounds.* A **clean or aseptic wound** is one to which no germs have gained access; the best example of it being a wound made by the surgeon's knife. An **infected or septic wound** is one in which there have been introduced pus-producing organisms (*see* inflammation), or such organisms as produce tetanus or lockjaw, gas gangrene, or hydrophobia. A **poisoned wound** is one in which some nonliving poison, as distinguished from bacteria or microörganisms, has been introduced by the agent causing the wound; e. g., bites of insects, scorpions, snakes, etc.

An **incised wound** is one made by a sharp cutting instrument, the class of wounds commonly known as cuts. A **lacerated wound** is the result of the tear-

ing of the skin and underlying tissues by blunt instruments or machinery and presents ragged edges, which do not retract much, and which, as a rule, consist of masses of torn tissues, frequently with dirt ground into them. A **contused wound** is one in which the division of tissue is accompanied by more or less severe crushing. A **punctured wound** is deep and narrow; e. g., stabs are punctured wounds. **Crushed wounds** are more serious than they first appear, due to the fact that the dead tissues are an excellent culture medium for the growth of microörganisms of infective inflammation, resulting sometimes not only in loss of the part but also in general infection of the body, that is, septicæmia or blood poisoning. The term **gunshot wound** is applied to any wound inflicted by the missile of a weapon of warfare, such as by rifles, pistols, cannon, etc.

When the skin and underlying tissues are divided, blood vessels, generally capillaries, also are divided, and there is more or less bleeding from the cut surfaces of the tissue, a clot forming between the cut surfaces. Young connective-tissue cells and capillary buds grow into this clot from the edges of the wound, replacing the blood elements. These young connective-tissue cells and the young capillaries form what is known as granulation tissue or "proud flesh." Later the young connective-tissue cells and capillary buds develop into the mature connective tissue, and the epithelium of the skin grows over it from the edges of the wound. When the cut surfaces are so close together that there is very little granulation tissue required to heal the wound, healing is said to be by *first intention;* when the wound is gaping and considerable granulation tissue is required, healing is said to be by *second intention.* Pus infection causes gaping of wounds, therefore in wounds infected with pus bacteria, healing is by second intention. Connective tissue filling in a gaping wound forms the so-called "scar."

Unless cut ends of tendons are brought together, the two ends will be so retracted, and there will be so much connective tissue formed between them in the healing of the wound, that the function of the tendon will be lost. Unless the cut ends of a nerve trunk are brought together, the function of that nerve will be lost forever. Nerve fibrils making up a nerve trunk regenerate centrifugally, and if the pathway for this regeneration is blocked by a wall of connective tissue, these fibrils can never reach the part they are supposed to innervate.

The local factors preventing and delaying the healing of wounds are: Infection with pus bacteria; the presence in the wound of foreign bodies, such as dirt, bits of clothing, etc.; and a lowered vitality of the edges of the wound due to crushing and tearing of the tissues, etc. General and constitutional factors also prevent and delay healing, among these factors being poor circulation of blood, diabetes, Bright's disease and syphilis.

General principles underlying the treatment of wounds.

Stop hæmorrhage and treat shock; so handle the wound as not to introduce fresh bacteria of infection; remove foreign bodies, such as dirt, bits of clothing, etc., from the wound; if infective bacteria already have been introduced into the wound, take measures to eliminate them or prevent their development. If the wound is an aseptic one, bring the edges together so that it can heal by first intention; if the wound is an infected one, keep the wound open and furnish drainage (*see* inflammation); if the wound is a poisoned one, neutralize the poison in it and prevent its entrance into the general circulation; treat any constitutional condition which may delay or prevent healing.

There are two main types of bacteria commonly causing infection in wounds: *Aërobic* and *anaërobic.* The former are bacteria that live and multiply in the

presence of air, while the latter are bacteria that live and multiply in the *absence* of air. The principal bacteria which cause infective inflammation and *septicæmia* or blood poisoning are *Streptococci*, some varieties of which are hæmolytic (destroy red blood cells), *Staphylococci*, and *Pseudomonas aëruginosa* (Bacillus pyocyaneous), frequently called the bacillus of green or blue pus; these are aërobic. There are several anaërobic bacteria which are frequently present in wounds. They commonly inhabit the intestinal tracts of man and other animals and are often found in soils which have been fertilized with animal manure. Among those occurring in wounds, especially in war wounds, are the *Clostridium welchii*, commonly termed the "gas bacillus" and causing gas gangrene, the *Clostridium sporogenes*, the *Clostridium œdematiens*, and the *Clostridium histolyticum*. The *Clostridium tetani*, or tetanus bacillus, is common in the fæces of horses and cattle and consequently is found with great frequency in soils fertilized with manure from those animals. It is often associated with Clostridium welchii in wounds and it produces a toxin which is one of the most powerful poisons known, being said to be 20 times as poisonous as dried cobra venom. The filtrable virus causing rabies, often termed hydrophobia (fear of water, and a common symtom of the disease) is nonpathogenic and perhaps anaërobic in character.

Inasmuch as the bacteria of pus infection are present everywhere, any wound is likely to be infected with them. However, contused and lacerated wounds are most likely to suffer from infective inflammation, owing to the lowered vitality of the tissues. The bacteria of tetanus or lockjaw and of gas gangrene are found in exceptional numbers in the intestinal contents of herbivorous animals, such as horses and cattle, and, for that reason, wounds inflicted by objects which have been contaminated by manure or by heavily fertilized soil are most liable to have introduced into them the bacteria of these diseases. In badly lacerated wounds and in punctured wounds there is great likelihood of absence of air due to the flapping back of the torn tissues after infliction of the wound, and for this reason these types of wounds afford a very favorable environment for the development of tetanus or gas gangrene. Tetanus, or lockjaw, frequently occurs after stepping on a nail near a barn or a stable, the nail previously having become infected with Clostridium tetani from the excretions of horses or cattle. The virus of rabies is found in the saliva of a rabid animal and is introduced by its bite. These bites generally are either lacerated or punctured wounds, with their associated anaërobic conditions.

A wound dressing consists of everything used to cover or dress a wound. The pad which is put directly over the wound is called a *compress*. In ordinary emergency treatment a wound dressing consists of a compress with bandage to hold it on. A dressing may be either dry or wet, aseptic or antiseptic. An *aseptic dressing* is one which is sterile, that is, one with no bacteria on it. An *antiseptic dressing* is one which, in addition to being sterile, contains some substance for killing bacteria. A *wet dressing* generally is an antiseptic dressing. A *wet antiseptic dressing* generally is used in wounds where infective inflammation is going on, whereas a *dry sterile dressing* is used to cover a recent wound which is considered to be free from infection. The purpose of a wound dressing is to stop hæmorrhage, to prevent introduction of bacteria, and to prevent further injury to the wound.

The Navy supplies a first-aid packet which is a hermetically sealed tin can containing a dry sterile dressing. This is excellent for a small wound. The directions for its use are contained in the packet. For large wounds, sick bays aboard ship are furnished with large and small shell-wound dressings. All these dressings consist of a sterile gauze compress with bandage attached. Any

piece of cloth, such as gauze, cotton, linen, muslin, or a handkerchief, is suitable for a compress in case of emergency, *provided it is rendered sterile,* and anything that can be used for bandaging is suitable as a bandage. The most vital point about material used as the compress of a wound dressing is that, before it is applied to a wound, it should be rendered sterile.

The part of the dressing which is to come in contact with the wound must be kept absolutely sterile; i. e., it must not be touched with any part of the body or anything else except sterile instruments before its application to the wound. In an emergency, material to be used in a wound dressing may be sterilized by boiling it for 10 minutes.

When a patient can be brought under the care of a medical officer in the very near future, the procedure necessary in the first-aid treatment in the case of ordinary wounds is: Stop the hæmorrhage, treat the shock, and apply a sterile dressing to the wound. If a surgeon is not available, the wound must be further treated as described hereafter.

In treating a freshly made wound suspected of being contaminated (all wounds should be suspected of contamination by infective organisms unless made under strictly aseptic precautions) the following procedure is recommended: Cleanse one's own hands as thoroughly as possible by a thorough scrubbing with soap and hot water, followed, if possible, by immersion of the hands in hot 1–2,000 bichloride of mercury solution and then in 70 per cent alcohol. Sterilize all instruments to be used in removing foreign bodies such as dirt, glass, splinters, etc., or for shaving the skin about the wound. If there is much bleeding, arrest the hæmorrhage. If there is much hair about the part, remove it by cutting or shaving for a distance of several inches from the cut edges. If there is much grease in and about the wound, remove it with turpentine or gasoline. Remove all foreign particles with sterile forceps. Clean the skin about the wound with a sterile damp cloth, and, while doing this, protect the wound with a piece of sterile gauze. Dry the wound and skin about it with sterile dry cloth or cotton. Apply tincture of iodine to all parts of the wound and to the skin about the wound for a distance of about one-half inch beyond the wound edges. After the skin has been well dried, the wound edges are brought together and a dry wound dressing applied.

There is no substance which should be used by the first-aid man to wash a wound. In the first place, he only washes in more dirt than he washes out, and, secondly, ordinary water is dangerous, as it contains many bacteria; this applies equally to soap and water. Strong antiseptics such as bichloride of mercury or phenol (carbolic acid) will destroy the cells of the body which dispose of the pus bacteria before they kill the latter, and should never be used except in certain wounds described later. Peroxide of hydrogen is not strong enough to kill all bacteria, and in a large or deep wound it washes some of these bacteria to uninfected parts which then become infected. Therefore, use none of these preparations in a wound, which should be covered with a sterile cloth, while cleaning the skin around the wound as described before. If, however, there is much greasy dirt rubbed into the wound, the latter should be gently swabbed out with sterile gauze or a cotton applicator, saturated with benzine or gasoline, and foreign bodies picked out with sterile forceps. *Tincture of iodine is the only substance to be used in an ordinary fresh wound by the first-aid man, aside from benzine and gasoline to cut grease, if present.* The tincture of iodine should be used within two hours after the wound is inflicted, as after that time it is probably valueless. Tincture of iodine is best applied with a camel's-hair brush, but a bit of cotton on a stick answers the purpose very well; the brush or cotton need not be sterilized, as the iodine accomplishes this. The tincture

of iodine may be poured into a wound. Iodine can be used in wounds practically anywhere in the body except in or near the eyes, *where it must never be used.* It *must not be used* in conjunction with bichloride of mercury.

Attempts to bring the wound edges together should not be made when the patient can be brought under the care of a surgeon in the very near future, but if hours or days must elapse before the service of a medical officer can be obtained, coaptation should be done in cases requiring it. The edges of a wound should not be brought together before foreign bodies and dirt have been removed and wound edges cleaned. Wounds in which infective inflammation is going on should be left open and allowed to drain. The two methods by which coaptation may be accomplished are by means of *sutures* and by means of *adhesive strips.* The former is preferable, as by the latter method bacteria of infective inflammation most probably will be introduced. As a rule, the edges of large deep wounds should not be too tightly apposed. Some chance of escape should be left for the serum and blood which are sure to be present, that is, means for drainage should be supplied. This may be done by the use of small pieces of sterile rubber tubing, strands of catgut or silkworm gut, or a narrow strip of gauze which has been sterilized by boiling. These drains should be placed in the lower angle of the wound. Wounds which are dirty and look badly should be left wide open.

The materials ordinarily used for sutures are *plain catgut, chromicized catgut, kangaroo tendon, silkworm gut, silk,* or *linen;* sometimes *horsehair* also is used. *Suture material,* also called *ligatures,* is divided into absorbable and nonabsorbable ligatures. *Absorbable ligatures* are those which can be left in a wound, inasmuch as the tissues absorb them, and included in this class are catgut and kangaroo tendon. Silkworm gut, silk, linen, and horsehair are *nonabsorbable ligatures* and must be removed after 6 or 7 days. *Chromicized catgut* is catgut which has been so treated that it is not as quickly absorbed as plain catgut. Catgut is the ligature to be preferred in the suturing of wounds. *Needles* used in the suturing of wounds are: *Curved, straight,* and *round,* or *cutting.* Where the skin must be pierced, the curved cutting needle is preferable. The main point about all suture material to be used in a wound is that it must be sterile. In case of emergency, an ordinary sewing needle with cotton or silk thread, well sterlized by boiling, may be used. This suture is nonabsorbable and must be removed after 6 or 7 days. With the operator's hands, and also the wound, well cleansed, the needle, threaded with the suture, is passed through the skin about one-eighth of an inch from the cut edge and on out through the opposite side at a corresponding point. The suture then is tied, and the ends cut, leaving about one-quarter of an inch remaining; care should be taken in tying the suture to use but little tension, sufficient only to bring the cut edges in accurate approximation. The remaining stitches are inserted in the same manner at a distance of from one-quarter to one-half of an inch apart until the wound is closed. When a tendon or large nerve has been cut, the ends must be brought together and sutured with catgut before the wound is closed. Suturing of tendons and nerves should be done by medical officers.

The manner in which a wound showing evidence of infective inflammation is treated, is: Elevate the part; put it at rest; remove foreign bodies, if present; remove enough sutures, if present, to obtain good drainage; insert drain; apply a wet antiseptic dressing; and treat the constitutional symptoms.

Wet antiseptic dressings generally are made up of a layer of sterile gauze, saturated with an antiseptic solution, to be applied directly on the wound. A layer of sterile cotton is then applied, some impervious material such as oiled

silk or waxed paper put over the dressing in order to retain the moisture, and a bandage over all. The dressing should be kept wet with the antiseptic solution, either by frequent changing or by having perforated rubber tubes between the gauze and cotton through which the dressing can be periodically moistened with the antiseptic solution. The antiseptic solutions usually employed in wet dressings are: Bichloride of mercury solution 1–5,000; saturated solution of boric acid; and Dakin's solution. *Bichloride of mercury solution* should not be applied on a wound freshly painted with tincture of iodine, as a corrosive iodide of mercury is formed which causes a very severe inflammation followed by ulceration.

If the symptoms of an infected wound are severe, put the patient to bed, clear out the bowels with a brisk purgative, and apply an ice cap to the head to reduce the fever.

The measures taken in fresh wounds suspected of being infected with tetanus or gas gangrene are: The wound is cleaned and treated as has been described, and kept freely open for a time in order that anaërobic conditions may not exist for the growth of these bacteria. As a further precautionary measure, tetanus antitoxin is given. A punctured wound suspected of being infected is frequently cauterized and a dry wound dressing applied.

Symptoms and treatment of special types of wounds.

Wounds *inflicted by an animal suspected of being rabid or of having rabies* are to be treated in the following manner: Thoroughly cauterize the wound with fuming nitric acid and neutralize with sodium hydrate solution, 1 per cent, or sodium bicarbonate solution, 10 per cent. The Pasteur treatment may be given later. In the absence of fuming nitric acid, a red-hot needle may be used to cauterize the wound. *Do not use silver nitrate or phenol for cauterizing these wounds* as they coagulate the albumin in the tissues thereby producing the anaërobic conditions necessary for infective organisms and retarding their destruction. Apply a dry wound dressing.

Poisoned wounds due to causes other than to bites of poisonous snakes include *ordinary insect bites,* such as those produced by mosquitoes, fleas, ants and bees. These bites require but little treatment. Sometimes the sting of a bee is broken off and remains in the skin. In treating these cases always search for the sting and remove it if it be present. As the poison of insects is composed chiefly of an acid, the local application of some alkali should be employed; either water of ammonia or a solution of washing soda affords great relief. *Bites of the more poisonous spiders, centipedes, tarantulas, and scorpions* require prompt treatment. Tie a ligature or tourniquet about the injured part between the wound and the heart to prevent the absorption into the general circulation; enlarge the bite by making an incision at its site, suck out the wound to produce bleeding, and apply crystals of potassium permanganate or tincture of iodine. If there be abrasions or open lesions in the mouth, it is not advisable to suck the wound. Release the tourniquet after a time to permit temporary restoration of circulation, replace it and repeat this process every half hour as long as may be necessary. Apply a wound dressing to the wound and treat shock which sometimes occurs in these cases.

Poisonous snakes are classified into *viperine snakes* and *colubrine snakes.* To the viperine family belong the *rattlesnake,* the *copperhead,* the *water moccasin,* and the *viper;* to the colubrines belong the *cobra* and the *coral snake.* In poisonous snakes the teeth are arranged in two rows, with a fang on each side, outside the teeth near the point of the jaw. Nonpoisonous snakes have four rows of teeth without fangs (fig. 48). The imprint of the wound often

will tell whether a person has been bitten by a poisonous or a nonpoisonous snake. The venom of different poisonous snakes differs in its action. The poisonous constituents are *neurotoxin*, a nerve poison, and *hæmorrhagin*, which injures the lining of the blood vessels so that an escape of blood occurs into the surrounding tissues; a third constituent is *hæmolysin*, which destroys red blood cells. The venom of colubrine snakes is made up principally of neurotoxin and that of viperine snakes of hæmorrhagin. In *colubrine poisoning*, the local symptoms are not marked, though there are at times severe pain and some

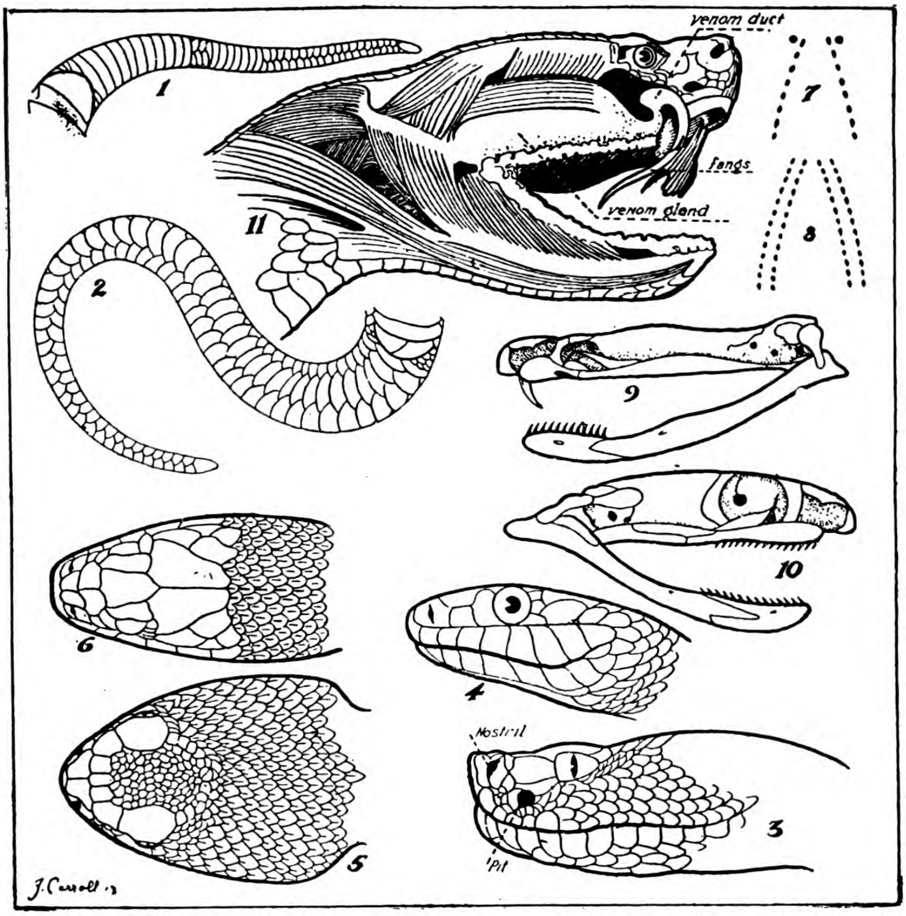

FIGURE 48.—1, Single row of scales, posterior to vent (poisonous snake—water moccasin); 2, double row of scales of harmless snake (*Natrix*); 3, side view of head of pit viper; 4, side view of head of harmless snake; 5, dorsal view of pit viper; 6, dorsal view of harmless snake; 7 and 9, bite puncture and skull of *Elaps;* 8 and 10, the same of harmless snake; 11, poison apparatus of rattlesnake. (Stitt.)

tenderness, swelling, and discoloration at the site of the bite; then in 1½ to 2½ hours the patient begins to feel tired and drowsy, there often being some nausea and vomiting; paralysis sets in, generally affecting the extremities first and then becoming more generalized, finally affecting respiration, so that the patient's breathing becomes slow and shallow and finally ceases; convulsions also may be present. In *viperine poisoning* there is pain at the seat of the bite, which soon becomes excrutiating, with rapid swelling and discoloration; there is at the same time a feeling of nausea and faintness, while a sense of depression takes hold of the individual; the pulse becomes rapid and feeble.

and the breathing is labored; in fatal cases, death may occur in 24 to 48 hours. The severity of the symptoms and final outcome depend upon the amount of venom injected and absorbed into the general circulation, which in a large measure depends on the size of the snake.

The **treatment** of wounds inflicted by a poisonous snake follows: If the wound is in an extremity, tie a bandage or handkerchief tightly about the single-bone part of the limb between the wound and the heart; incise the wound freely and suck out as much of the poison as possible. If there be abrasions or open lesions in the mouth it is not advisable to suck the wound. With a hypodermic syringe, inject a 2-per cent solution of potassium permanganate into and about the bite to destroy any poison which is left. Meanwhile, give stimulants in the shape of coffee and strychnine, one-thirtieth grain. The ligature should be loosened about every half hour to allow restoration of the circulation, but should be tightened up immediately if symptoms of general poisoning occur. There are antivenin serums available for the treatment of poisoning by snake bite, one which neutralizes neurotoxin and another which neutralizes hæmorrhagin. They are injected hypodermically or intravenously and are very effective if properly used; that is, serum to combat the venom of a colubrine snake must be used against that type of snake bite, and the specific serum for the viperine snake venom used to combat the toxin of that type of snake, in order to get results.

Gunshot wounds inflicted by bullets.—Always look for the wounds of entrance and of exit and apply a sterile dressing to each. Concealed hæmorrhage and injury to internal organs are the most dangerous results of these wounds and depend on the course taken by the bullet. The wounds of entrance and exit caused by high-velocity bullets may be so small as to be hardly visible, or the wound of entrance may be very small and the wound of exit large, due to the explosive effect of the bullet on the tissues. *Never probe a bullet wound,* as a bullet is very likely to be sterile, and by probing one is almost sure to introduce germs of infective inflammation.

Symptoms and treatment of penetrating wounds of the chest.—The symptoms are the presence of air bubbles in the wound, difficult breathing, coughing, and spitting of blood. The first-aid treatment consists in laying the patient on the injured side, firmly bandaging the chest, summoning medical aid, and the general treatment for wounds.

Symptoms and treatment of wounds of the abdomen with injury to the intestines and stomach.—The signs of injury to the intestines are the escape of gas or fæces through the wound and the passage of blood in the stools. Injury of the stomach may result in the escape of its contents through the wound and the presence of bloody vomitus. Keep the patient absolutely quiet and place under the care of a surgeon as soon as possible, as every moment's delay in surgical treatment lowers his chance of recovery. With a large abdominal wound from which more or less of the abdominal contents escape, place a sterile cloth over the wound and the extruded intestines; bandage in place and keep the dressing wet with sterile physiological salt solution until the patient can be placed under the care of a surgeon.

Treatment for wounds of the eye.—Remove the foreign body, if present, as described under removal of foreign bodies. Never use tincture of iodine or other strong antiseptics in the eye. Boric acid solution or an organic silver preparation (silvol or argyrol) are the only antiseptics to be used in the eye. All eye wounds should be brought under the care of a medical officer as soon as possible. In the meantime cover both eyes with absorbent cotton or soft cloths so as to keep the eyelids still, and hold the dressing in place with bandages

around the head. Be careful not to put on these bandages so tightly that they will cause pressure on the eyeball. In case some time must elapse before the services of a medical official can be obtained, the dressing should be kept wet with cool saturated solution of boric acid, and if secretions are present, the eye should be irrigated at frequent intervals with warm saturated solution of boric acid. In lifting the eyelid do not press on the lid, but lift the upper lid by traction on the region above it; this prevents scratching of the cornea by pressure.

CONTUSIONS, STRAINS, AND SPRAINS

A contusion, or as it is commonly termed, a *bruise*, is a crushing and tearing of the tissues, usually without a break in the skin. It is characterized by swelling, tenderness, and discoloration, due to the rupture of blood vessels in the neighborhood of the injury. At first the discoloration is red, then blue or black, and finally turns yellow or green, commonly called black and blue spots. The change in color is due to the chemical change in the coloring matter of the blood hæmoglobin. The rapidity in the formation of the swelling and its size depends on the number and size of the blood vessels ruptured. Contusions vary in extent from an ordinary black and blue spot to the almost complete pulpification of a limb with laceration of blood vessels and nerves such as sometimes occurs in railway or other accidents. A "black eye" is an example of a contusion.

Slight contusions as a rule require no treatment. With severe contusions there is more or less shock which must be treated. For the contusion itself, the **treatment** is to stop the subcutaneous hæmorrhage; this can be done by rest and elevation of the part; by very hot or cold applications; and if the injury is in a limb, firm, even pressure of a bandage may be effective. Later, when the bleeding has ceased, the absorption of the extravasated blood may be hastened by hot fomentations and massage. In the case of severe contusions and in contusions in elderly people, hot water is much better than cold, as the latter ends to lower the vitality of injured tissue.

A strain is the overstretching of a muscle or tendon with an attendant rupture of the muscle or tendon fibers. In severe strains, small blood vessels often are ruptured, resulting in the escape of blood into the muscles in the same way that, in the case of a bruise, blood escapes beneath the skin. It is generally the result of violent exertion or sudden unexpected movement. The symptoms are pain in the affected muscle, stiffness, lameness, and more or less swelling. If complete rupture occurs, there will be loss of power of the affected muscle and on examination there will be found a distinct gap with considerable swelling above it, due to retraction of the muscle fibers.

For slight strain, the **treatment** consists of strapping with adhesive plaster or bandaging, which, with rest, gives the most comfort. After 2 or 3 days, graduated massage may be given. If rupture occurs, in the absence of surgical assistance immobilize the part by splints or bandages and place the part in such a position that the muscles are relaxed, thus allowing the torn fibers to come together.

A sprain is an injury to a joint due to wrenching or twisting its ligaments and adjacent soft parts. There usually is a momentary dislocation and automatic reduction of the joint affected. There also may be injury to cartilages, and even portions of bone to which the ligaments are attached may be torn away. Accompanying these injuries there is more or less escape of blood into the joint itself and surrounding tissues, resulting in severe pain and marked swelling of the injured part. Later, discoloration develops at the site

of injury. Sprains of the ankle and wrist are the most common. Frequently it is difficult to determine whether or not a sprain is not complicated with fracture. An X-ray examination is always advisable to determine the presence of a fracture in these cases.

In the **treatment** of sprains all severe cases should be brought under the care of a medical officer, particularly as the condition may be complicated with fracture. Elevate the joint and apply very hot or very cold water for one-half an hour to an hour to stop the subcutaneous hæmorrhage; then apply a tight bandage and keep the joint at rest in order to give the torn ligaments and tissues a chance to heal and the effused blood to be absorbed. Treatment of a sprain of the ankle by immediate strapping of the joint and allowing the patient to walk about may be practiced in the less severe uncomplicated cases. For this purpose strips of adhesive plaster 1 to 1½ inches wide and about 18 inches long should be obtained. A strip is started well behind at the junction of the lower and middle third of the leg of the injured side, and is carried down under the heel with considerable tension, across the sole and up the other side of the joint. (Fig. 49.) The middle of another strip is applied to the point of the heel and the two ends are carried forward over the foot, but not far enough to meet. Leg strips and foot strips alternate, interlacing with each other and overlapping about one-third of the previous strip each time until the ankle joint is covered. (Fig. 50.) Strapping in this manner furnishes pressure and at the same time fixes the joint and gives support to the torn ligaments. If any individual is unable to walk immediately after injury to the ankle, the injury should be considered as a fracture until proved otherwise.

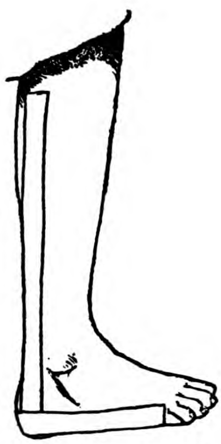

FIGURE 49.—Strapping of ankle; first step. (Owen.)

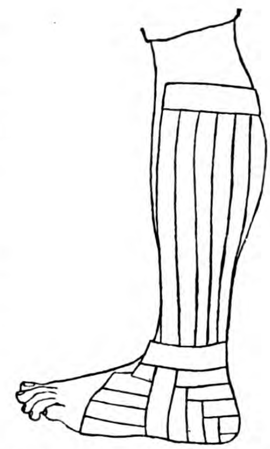

FIGURE 50.—Strapping of ankle; completed. (Owen.)

DISLOCATIONS

A **dislocation** is a slipping away from each other of the bones which form a joint, resulting usually in a locking of the bones in a new position. Necessarily the dislocation is attended with tearing of the ligaments, and often with rupture of the muscular attachments as well, except in a joint which, on account of frequent prior dislocations, has had its ligaments so stretched that not only is dislocation easy but no tearing of the ligaments results. As a result of the tearing of structure about the joint, there is also rupturing of the blood vessels, with consequent swelling and discoloration.

Dislocations must be differentiated from fractures and sprains. In all three conditions there may be swelling and pain in the neighborhood of a joint. In fracture there is an unnatural movement of the bone between the joints instead of immobility at the joints as in dislocations, and the movement is attended with a grating sound and sensation; the deformity is in the bone between the joints in fractures, whereas the deformity is at the joint in dislocations. In dislocations there is immobility at the joint and between

the joints, and the head of the dislocated bone may be felt in an abnormal position. In sprains there is absence of any of the symptoms of dislocation except swelling and pain. As a rule sprains are momentary dislocations in which the head of the bone has slipped back into place. All cases, if facilities are available, should be X-rayed before and after treatment.

The **treatment** consists in restoring the bones to their normal positions, spoken of as "reducing the dislocation," and then so confining the parts that a recurrence of the trouble will be improbable. The joint should be immobilized until the rents in the ligaments have healed. While some dislocations slip easily back into place, to properly reduce the majority requires considerable knowledge, skill, and either local or general anæsthesia. Without careful manipulation blood vessels and nerves not only may be injured but a simple dislocation may become complicated with fracture. In view of this, if surgical aid can be obtained within a day or two, do not attempt to reduce a dislocation, except perhaps in case of the jaw and finger; loosen the clothing about the injured part and support it as comfortably as possible in the new position, or if the patient must be moved, support the limb in a sling or by splints and bandages, and summon surgical assistance. If, however, surgical assistance cannot be had for some time, 3 or 4 days, careful attempts should be made to reduce the dislocation, as the head of the bones concerned most probably will become bound by connective tissue formation and then reduction will become next to impossible without an operation. Shock is often present with major dislocations and should be treated.

Treatment of certain dislocations.

Dislocation of the jaw.—In this condition the patient cannot speak or close his jaws. The dislocation is due generally to a blow upon the mouth when open or by yawning or laughing. This dislocation usually is reduced without much difficulty, but there is great danger of the thumbs of the operator being bitten. Wrap the thumbs well with a handkerchief or bandage, stand in front of the patient, and while pressing with the thumbs in the mouth just back of the last lower molars, at the same time lift up the chin with the fingers. The jaw usually will snap at once into place, and the thumbs must be quickly withdrawn to prevent them from being bitten. After reduction, no further treatment is indicated, but the patient should be advised to open the mouth no oftener than necessary.

FIGURE 51.—Backward dislocation of finger; reduction by extension. (Hamilton.)

Dislocation of finger joints.—With a dislocated finger joint, pull on the dislocated end, at the same time bending it backward if the dislocation is forward, or forward if the dislocation is backward, and pushing the joint into place; strap or splint the finger (fig. 51).

FIGURE 52.—Subglenoid dislocation of the shoulder. (Mason.)

Dislocation of the shoulder.—In this dislocation the arm is held rigid, the elbow stands off a distance of 3 or 4 inches from the body, and the shoulder appears flat with a marked depression beneath the point of the shoulder. In addition there is pain and swelling at the site of injury, and the head of the humerus can be felt in an abnormal position as compared with the other side. Do not try to reduce this dislocation if surgical assistance can be had in a few days; if not, try one of the three methods following.

(*a*) *Stimson's method.*—Place the patient on a canvas cot or stretcher lying on the injured side, arm hanging through a hole made in the cot or stretcher in the median line at a distance of about 18 inches from the head end. The cot or stretcher first should be elevated from the floor by means of chairs or blocks so that the arm does not touch the floor. Fasten a 10-pound weight on the dependent arm, and, in from 5 to 10 minutes, the muscles usually have become sufficiently relaxed to allow the head of the bone to slip into its proper place of its own accord. If it should not do so, the weights should be removed and the arm carefully brought to the patient's side against the operator's fist, held in the armpit. This should force the head of the bone back in place. Apply a Velpeau or Desault bandage without the pad in the armpit and keep the arm bandaged for a week.

(*b*) *Kocher's method.*—The patient should be in either the sitting or standing posture, preferably the former. Grasping the affected arm at the elbow and wrist, flex the elbow to a right angle and press the arm against the chest (fig. 53). Turn the forearm as far as possible from the chest by external

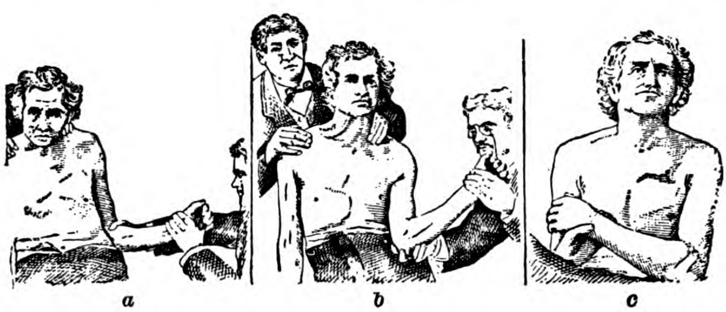

FIGURE 53.—Kocher's method of reduction by manipulation: *a*, First movement, outward rotation; *b*, second movement, elevation of the elbow; *c*, third movement, inward rotation and lowering of the elbow. (Ceppi.)

(outward) rotation of the humerus. Maintaining this external rotation, carry the elbow slowly inward across the front of the chest to the center line of the body. With the arm in this position quickly rotate the forearm inward until the hand touches the sound shoulder. Lower the elbow. Immobilize the entire arm by the application of a special bandage of the chest or a Velpeau bandage without the axillary pad.

(*c*) *Reduction by traction or extension.*—Place the patient upon his back on the deck or table. The operator takes off one shoe, inserts his heel under the armpit of the dislocated side, and makes traction upon the arm downward and slightly toward the patient's body. In doing this, care must be taken not to employ too great leverage action upon the arms, as a fracture might be produced. After reduction, immobilize the joint with a Velpeau or Desault bandage without the pad in the armpit, and keep the arm bandaged for a week.

If a dislocation fails to be reduced by these methods, do not persist in attempting reduction, as it is then a case for operative surgery.

Dislocation of the elbow, hip, and knee.—These dislocations are not as common as shoulder dislocations. The bones may be displaced in various directions and their reduction is difficult and often dangerous. First-aid treatment consists in obtaining surgical assistance, making the patient comfortable with pillows, etc., and treating for shock, if present.

Compound dislocations are those in which the head of the bone has been forced through the skin and underlying tissues. Here not only the dislocation

but also the wound must be treated. A **complicated dislocation** is one in which a large blood vessel or nerve has been injured.

FRACTURES

A **fracture** is the forcible solution of the continuity of a bone. Fractures are classified as *simple* or *closed*, and *open* or *compound*. A simple or closed fracture is one in which there is no opening to the outside air. An open or compound fracture is one in which, by a break in the overlying skin and other tissues, there is direct communication between the outside air and the broken bone. A compound fracture is always very serious, owing to the likelihood of infection. In an infected compound fracture not only is it difficult to obtain union of the bones but there is danger to life from the infection itself. This element of infection is absent in simple fractures.

Careless handling of fractures may convert a simple into a compound fracture, and there is grave danger of injuring blood vessels, nerves, and other tissues in the neighborhood of the fracture (complicated fracture).

FIGURE 54.—Green-stick fracture.

FIGURE 55.—Comminuted fracture.

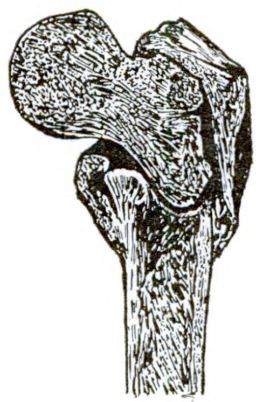

FIGURE 56.—Impacted fracture of femur. (Wharton.)

A *complete fracture* is one in which the bone is severed through its entire thickness. An *incomplete* or *green-stick fracture* is one in which the bone is broken or bent, but not broken entirely through (fig. 54). (It resembles the condition obtained from an effort to break a green stick.) A *multiple fracture* is one in which the bone is broken into more than two fragments, the lines of fracture not, however, communicating with each other. A *comminuted fracture* is one in which the bone is broken into several pieces, the lines of fracture communicating with one another (fig. 55). A *complicated fracture* is one accompanied by an injury to some surrounding part, as an injury to a joint, muscle, nerve, or blood vessel. An *impacted fracture* is one in which one fragment of the bone is driven into the other, the two remaining tightly wedged (fig. 56).

When a bone breaks, there is always an injury to the periosteum, or bone covering, and to the surrounding tissues. There is also hæmorrhage about the ends of the fragments, and the space between the two fragments rapidly becomes filled with a blood clot. This blood clot becomes organized as described in the healing of wounds, forming a callus which surrounds the ends of the

fragments, and, as it were, glues them together. At first the callus consists only of fibrous tissue, but later there is growth of bone cells, and a deposit of lime salts which changes the callus into dense bone.

The following factors may prevent the union of fractures: Infection preventing the formation of a callus; the interposition between the fragments of muscle or other tissue; improper reduction of the fracture; general constitutional conditions such as syphilis, tuberculosis, diabetes, Bright's disease, and an inability on the part of the patient's body to deposit bone in the callus. This latter condition in which fibrous tissue, but not bone, is deposited in the callus is spoken of as "fibrous union."

In the diagnosis of fracture the following conditions usually will be found: 1. There is a loss of power in the part, for example, if the leg is broken, the man has fallen and cannot arise; 2. The part is in unnatural position, and comparison of a fractured limb with the uninjured one will show that there is a deformity between the joints and that the injured limb is probably shorter; 3. Movement can be obtained where normally there is no motion, with grating of the broken ends of the bone (if an attempt to move the limb is made it will be found that there is movement in the bone between the joints where there should be none, and the broken ends of the bone grating together (*crepitus*) can be felt and heard); 4. There is history of violence and the patient will say that he heard the bone crack and give way; and 5. The patient complains of great pain and tenderness at the seat of fracture and there is swelling present, due to bleeding from the broken ends. Whenever a fracture is suspected or doubtful, an X-ray picture of the part should be obtained, as this is the surest means of determining fracture.

General principles for the treatment of simple fractures.

The patient should be brought under the care of a medical officer as soon as possible. The object of treatment before a medical officer can take charge of the case, if his services cannot be had promptly, is to prevent further injury, especially to blood vessels and nerves, and puncture of the skin by the sharp, knife-like edges of the broken bone, and to treat shock if it is present. The patient should be placed in a comfortable position while waiting for the medical officer or surgeon, and if it is necessary to move the fractured part in doing this or in treating shock, one hand should support the broken bone on each side of the break. The bone must not bend at the break while the patient changes his position to a more comfortable one. Support the broken bone in a natural position on a pillow or folded coat, great care being taken that it is not bent or does not drag on the point of fracture. If there is doubt as to whether or not a fracture is present, do not manipulate the part, but treat it as a fracture until the arrival of a surgeon. Do not move the patient more than is necessary before the fracture has been set and secured. If the injured person is wearing thin summer clothing, it will not always be necessary to remove it; if thick clothing is worn, however, it is difficult to determine whether or not a fracture has occurred or the character of the injury. In the latter case, never try to take off the clothing, but cut it in the seams with a sharp knife or scissors. If the patient cannot be brought under the care of a surgeon for a day or more, the fracture must be set and immobilized as described hereafter. If a fracture is not set, it will unite in bad position and the bone will have to be refractured to secure proper alinement.

In the treatment of *compound fractures* the services of a medical officer should be obtained as soon as possible. In the meantime, treat the shock and the wound as described in the section on wounds. After treatment of the

wound, treat the fracture as described before. In case no surgeon is available for a day or more, the fracture may be set as described hereafter, always keeping in mind the proper treatment of the wound while so doing, thus preventing, as far as possible, infection which is a serious complication in fractures.

The setting of a fracture consists of bringing the two fragments in apposition and in holding them in that position. The force which keeps the fragments out of apposition and which must be overcome in order to bring them into apposition is muscular contraction. This muscular contraction is overcome by extension and counterextension. *Extension* is pulling the far or distal end of the limb, and *counterextension* is merely holding the near or proximal end next the trunk. Extension and counterextension must be applied until the deformity and shortening disappear and the two limbs look alike. Where the muscular contraction is great, as in fractures of the thigh, the fragments frequently cannot be brought into apposition without relaxation of the muscles by a general anæsthetic or by gradual tiring out of the muscles by a steady pull with weights and pulley. In these cases extension and counterextension frequently have to be applied for some time after the fracture has been set in order to maintain the fragments in apposition. The fragments of a fractured bone are held in apposition by means of splints, plaster of Paris bandages, ordinary bandages, etc.

Splints are agents for immobilizing a fractured part. There are two general classifications of splints, *traction splints*, and *coaptation splints*. Traction splints are those which, in addition to immobilizing a fracture, are constructed in such a manner that by their use extension and counterextension can be applied without the use of other apparatus for this purpose. Coaptation splints are those which are used solely to immobilize the fracture. Traction splints are indicated in fractures where there is much muscle pull tending to displace the fragments. The most common traction splints are: The *Thomas leg splint* and modifications of the same, the *Jones humerus traction splint, the Army hinged half-ring thigh and leg splint (Keller)*, the *wire ladder splint*, and the *Cabot posterior wire splint*. To obtain extension by use of these splints, adhesive strips or tapes are fastened to the skin and attached to the distal end of the splint, while counterextension is obtained by the push of the other end of the splint against the body.

In emergency any material which has sufficient firmness to give support to a limb will answer for coaptation splints. Examples are umbrellas, canes, swords, scabbards, guns, cigar boxes, wire, leather, laths, tent pins, pillows, or a folded coat. In fractures of the thigh and leg, the sound limb may be used as a splint. Plaster of Paris bandage may be used. Adhesive plaster generally is used to splint a fractured rib. The materials used for splints must be light but sufficiently rigid to prevent bending; long enough to fix into the joints above and below the fracture; broad enough to prevent pinching of the limb in bandaging; and sufficiently padded to protect the part from undue pressure.

Coaptation splints may be applied temporarily over the clothing and should always be well padded, as a hard board against an injured limb soon becomes very painful. Oakum, cotton, grass, moss, portions of clothing, or any soft material will answer for the padding. If possible, two splints should be applied to a limb, while in fractures of the leg three generally are used, one on each side and one behind. In applying splints, have an assistant hold them in position and then firmly fasten them to the limb by several turns of a roller bandage, adhesive strips, handkerchiefs, pieces of rope, or portions of clothing. While splints should be applied snugly, care should be taken

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not to apply them too tightly for fear of cutting off the blood circulation; leave the tips of the fingers and toes exposed and watch the circulation. If the tips of the fingers are blue and cold, or if, upon pressing upon the nails, the normal pink color does not quickly return, the dressing is too tight. Remember that although a splint may be applied with the proper degree of snugness, later swelling of the fractured limb may cause it to be too tight. The use of plaster of Paris as splinting material should be left to the surgeon.

Fractures of the skull are classified as *fractures of the vault* and *fractures of the base* of the skull. Fractures of the skull are dangerous on account of the probability of injury to the brain. In fractures of the vault, the danger lies in tearing of the brain tissue itself by the fragments of bone, and in tearing of the blood-vessel walls, resulting in hæmorrhage, with the resulting compression of the brain. Compression of the brain also may result from the displaced fragments of broken bone. In fractures of the base of the skull, the principal dangers are rupture of the meningeal arteries, resulting in intracranial hæmorrhage and compression of the brain. Both types of fracture may be compound, while there is the added danger of infection which, in fractures of the vault, occurs through injury to the overlying tissue at the site of fracture and, in fractures of the base, to infection from the nose and ears due to a tearing of the mucous membrane of the nose and middle ear.

In fractures of the skull, unless compound or depressed, all the usual symptoms of fracture are absent, or entirely overshadowed by the injury to the brain. The most prominent brain symptoms are loss of consciousness and paralysis; if the loss of consciousness is sudden, it is probably due to concussion or to the pressure of a piece of bone; if it comes on slowly, it is apt to be the result of hæmorrhage from a torn blood vessel. In fracture of the base of the skull, there may be bleeding from the nose or ears, or into the orbits, or under the conjunctiva; the escape of cerebrospinal fluid—a clear, watery serum—from the ears is considered a sure sign of fracture of the base.

In the **treatment** of a fracture of the skull obtain the services of a medical officer as soon as possible. In the meantime, keep the patient quiet, in a recumbent position, and apply an ice bag to the head; if the fracture is compound treat the wound. *Avoid stimulants.*

In **fractures of the spine** the spinal cord is generally injured or cut across, with resulting paralysis to all parts below the fracture. On passing the fingers down the spine, irregularity of the spinous processes with deformity will usually be noted; as well as local pain over site of fracture. Keep the patient perfectly quiet, and lying flat on his face until surgical aid can be obtained. If it is necessary to move him, it should be done with extreme care to prevent any additional injury to the spinal cord, and keeping him in a prone position, face down.

Symptoms and treatment for a fractured nose.—There is usually considerable deformity, the bridge of the nose being depressed and pushed to one side, crepitus generally can be felt, and there is considerable nosebleed. Return the bones to their normal position if possible, by gentle manipulation. To hold the bones in position, apply two very small rolls of narrow bandage on either side of the nose and hold the rolls in place with short strips of adhesive plaster. Check the bleeding by syringing the nostril with hot or cold water, or, if necessary, pack the nostrils with cotton. Warn the patient not to blow his nose.

Symptoms and treatment of fracture of the lower jaw.—In fracture of the lower jaw the line of teeth is irregular and there may be bleeding from the mouth; the patient cannot open his mouth, and by passing the fingers along

the line of the lower jaw localized pain and deformity can be noted (fig. 57). Push the bones into place and apply a four-tailed or Barton bandage. The patient must be fed through a tube and the mouth kept clean, as these fractures are generally compound. Place the patient under the care of a surgeon as soon as possible.

FIGURE 57.—Fracture of lower jaw, showing loss of alignment of teeth. (Scudder, modified.)

Symptoms and treatment of fracture of the rib.—The symptoms are pain or "stitch" in the side, and some difficulty in breathing. Pain may be especially severe if the patient coughs or sneezes, or breathes deeply. The danger in rib fracture is injury to the lung, and with this complication there may be spitting up of blood and escape of air beneath the tissues of the chest wall, a condition called *emphysema*. On examination, by passing the fingers along each rib in succession, one will be able to find a local point of tenderness, and often a false point of motion or grating in one or more of them. By placing the ear against the injured side and asking the patient to take a deep breath, grating may be heard distinctly. As it is impossible to

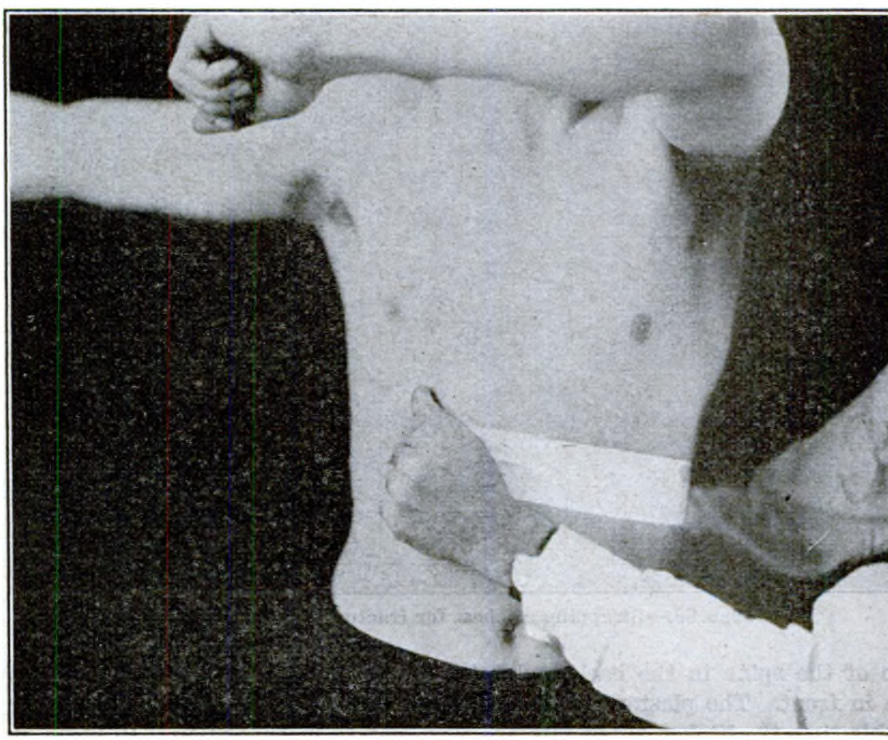


FIGURE 58.—Application of the first adhesive strap in fracture of rib (note elevation of arm and shoulder and application of strap from below upward).

splint only one or two ribs, in order to immobilize the fracture it is necessary to immobilize the whole side on which the fracture has occurred. This splinting can be temporarily accomplished with a broad binder of muslin, a triangular

bandage, or an ordinary roller bandage applied firmly around the chest, but the best method is to strap the chest with adhesive plaster. Procure a strip of plaster wide enough to cover the injured side, about 8 or 9 inches wide, and long enough to extend from the spine behind to just beyond the median line in front, and apply as follows: With the patient standing with arms above the head, tell him to let all his breath out, and as he does this quickly apply the plaster to the injured side, starting just a little to the other

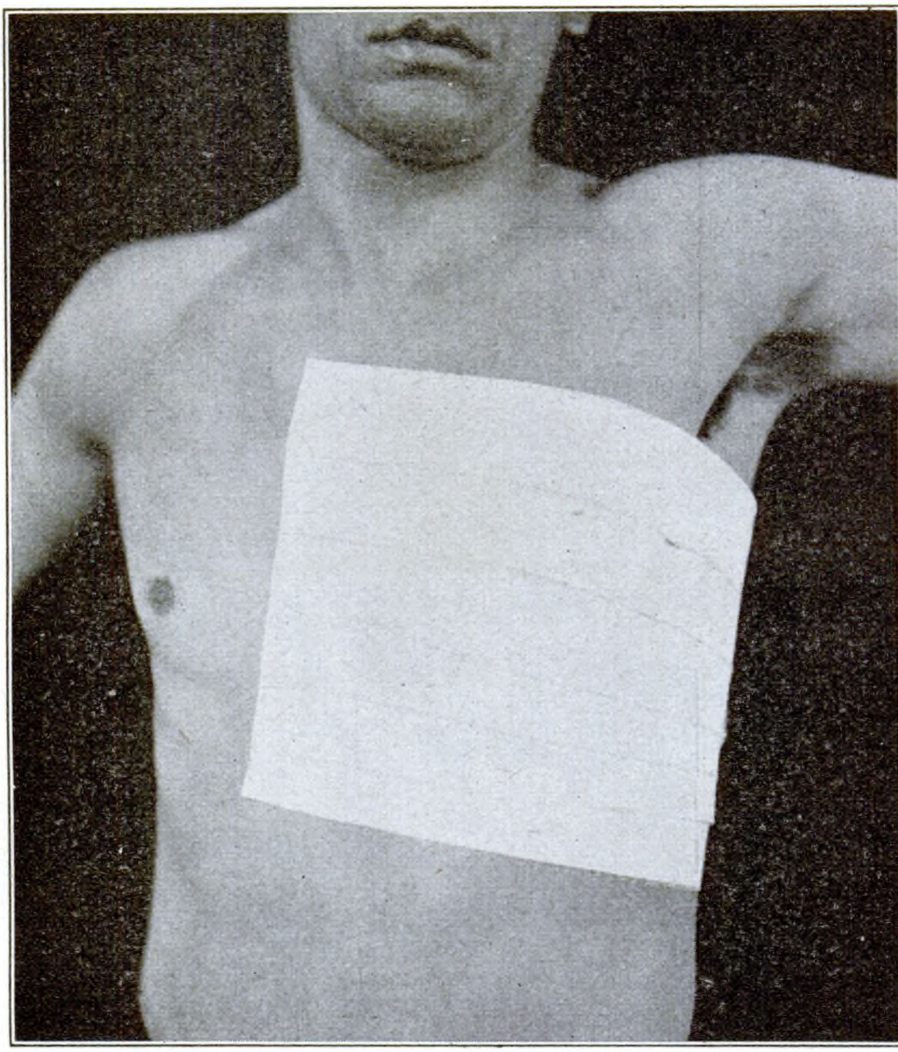


FIGURE 59.—Strapping of chest for fracture of rib; completed.

side of the spine in the back and bring the strap to just beyond the middle line in front. The plaster is applied at the end of a forced expiration because at this time the broken fragments are more nearly in apposition. In place of a single strip of plaster several strips, each about 2½ inches wide, may be applied, beginning well below the fracture and gradually working up (figs. 58 and 59). Apply each strip with firmness, at the end of a forced expiration, allowing it to overlap one-third of the one below. When there is injury to the lungs accompanied by spitting up of blood, keep the patient quiet in bed and give cracked ice by mouth.

Symptoms and treatment of fracture of the clavicle or collar bone.—In fracture of the clavicle the attitude of the patient is characteristic; the shoulder drops downward, inward, and forward, and he attempts to support it by holding the elbow of the injured side in the hand of the sound side. The collar bone lying immediately under the skin, the fracture is easily made out from the deformity and localized pain and tenderness. As an emergency dressing until the patient comes under the care of a surgeon, all that is required is a large arm sling with a pad in the armpit and the arm bound to the side. Later treatment, in the absence of a surgeon, consists in the application of any dressing which will keep the shoulder up, back, and outward, thereby holding the fragments in their normal position. This may be done by means of the Velpeau or Desault bandages or the Sayre dressing (*see* section on Bandages and Bandaging) or by the T-splint (*see* section on Splints and Appliances).

Symptoms and treatment of fracture of the humerus or arm bone.—Fracture of the humerus has all the general signs and symptoms of fracture. A fracture of the neck or upper third of the bone may be put up temporarily by placing a pad or folded towel in the armpit and securing the arm to the side with a bandage; then place a sling about the wrist. With this dressing the weight of the arm and forearm acts as an extension. Fracture in the middle of the shaft of the bone may be treated by the use of two broad splints or, better, four narrow ones, placed about the seat of injury and secured by a bandage or strips of adhesive plaster, the wrist being supported by a sling. Care must be taken that the splint does not extend too high in the armpit, as thus it might compress the blood vessels or at least be exceedingly painful. A fracture near the elbow joint may be dressed temporarily by simply applying a large arm sling and securing the arm to the body. Fractures in this locality are serious from the liability of the joint to become stiff, and the patient should be brought under the care of a surgeon as soon as possible.

Symptoms and treatment of fracture of the bones of the forearm.—When both bones of the forearm are fractured all the usual signs of fracture are present. When only one bone is broken, the other acts as a splint and but little deformity will be apparent, but there is inabilty to use the forearm, and on examination, tenderness and a false point of motion can be discovered at the seat of injury. With a fracture of the radius alone, low down and just above the wrist, there is a well-marked deformity, termed silver-fork deformity (fig. 60), which is a symptom of the fracture of the radius spoken of as *Colles' fracture.* In this fracture the tip (*styloid process*) of the lower end of the ulna is often broken off, there may be rupture of the internal lateral ligament of the wrist, and as the bones are usually impacted, no grating or crepitus is present. In treating fractures of the forearm, the limb should be put up with the elbow bent at a right angle, the forearm across the chest, with the palm of the hand turned in and thumb pointing upward. First reduce the deformity by gentle traction upon the hand, and then apply two well-padded splints to the seat of fracture, having them long enough to extend from the elbow to below the wrist; bandage the splints, and support the forearm by means of a sling. It is very important that all cases of Colles' fracture should be brought under the care of a surgeon as soon as possible, as, unless the fracture is properly reduced and treated, the deformity is apt to be permanent.

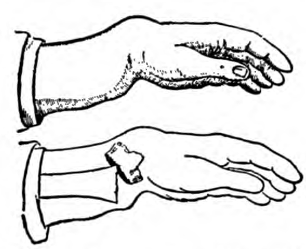


FIGURE 60.—Deformity at the wrist consequent upon displacement backward of the lower fragment of the radius after fracture at its lower extremity. (Levis.)

Symptoms and treatment of fracture of the metacarpals, or wrist bones.—Deformity and pain are the most prominent symptoms. Apply splints on the back and front of the hand, reaching from the finger tips halfway up the forearm.

Treatment of fractured fingers.—If only one finger is fractured, a narrow splint, such as a wooden tongue depressor (fig. 61), should be applied to the palmar surface of the finger and secured by strips of adhesive plaster. If several fingers are broken, it is better to place a pad in the palm of the hand and apply two well-padded splints, extending from below the tips of the fingers well up on the forearm.

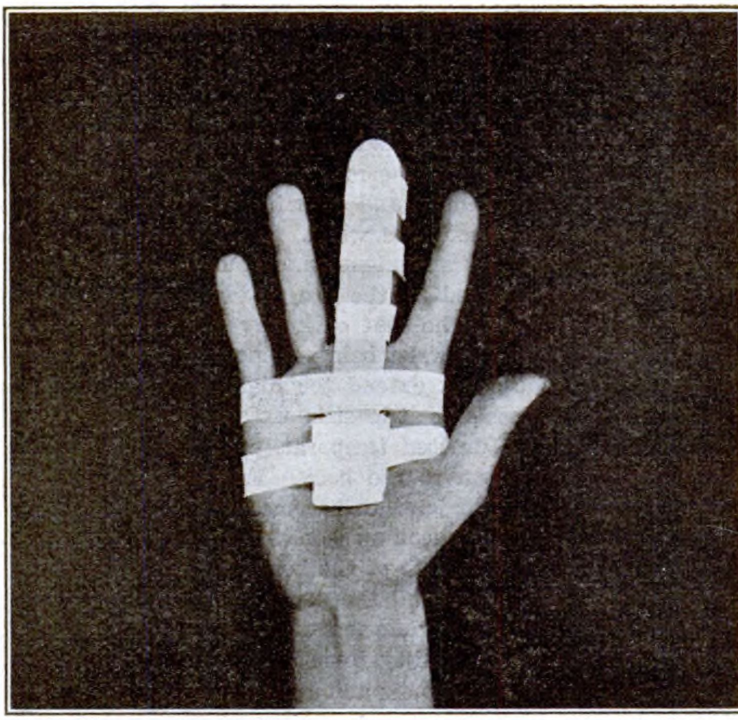


FIGURE 61.—Tongue depressor as a splint for fracture of finger.

Symptoms and treatment of fractures of the pelvis.—The patient is unable to sit up or stand and complains of great pain and a sense of coming apart. Crepitus may be felt on strong pressure. These fractures generally are accompanied with injury to internal organs and more or less shock. With injury to the bladder blood is passed in the urine. When fracture of the pelvis is suspected have the patient lie quietly on his back, apply a tight binder or bandage to the hips, and also fasten the knees together. He should be moved with great care and transported on a stretcher which will not sag. The patient's bed should be fixed so that it will not sag under his pelvis and the thighs should be supported with pillows. In case of bleeding from the bladder, which indicates a rupture of that organ, a catheter should be introduced and left in, so that the urine will not accumulate and escape into the peritoneal cavity. A urinary antiseptic (methenamine (urotropin)) should be administered by mouth.

Symptoms and treatment of fractures of the femur or thigh.—The patient usually lies with the toes of the injured limb pointing outward; any attempt to move the limb results in a spasm of the muscles and causes the patient excruciating pain; there is loss of power in the limb, the patient being unable to lift it. On examination, if the fracture is on the shaft of the bone, a false point

of motion is discovered. By measurements the fractured limb is found to be shorter than the other one, due to the pull of the powerful thigh muscles. Measurement should be made on each limb and compared by stretching a string from the anterior superior spine of the ilium to the internal malleolus with the patient on his back. Emergency treatment consists in applying two splints, one on the outside reaching from the armpit to beyond the foot and one on the inside from the crotch to the foot (fig. 62). The splints should be tied in five places—around the ankle, over the knee, just below the hip, around the pelvis, and just below the axilla. It is well also to tie the two limbs together. The

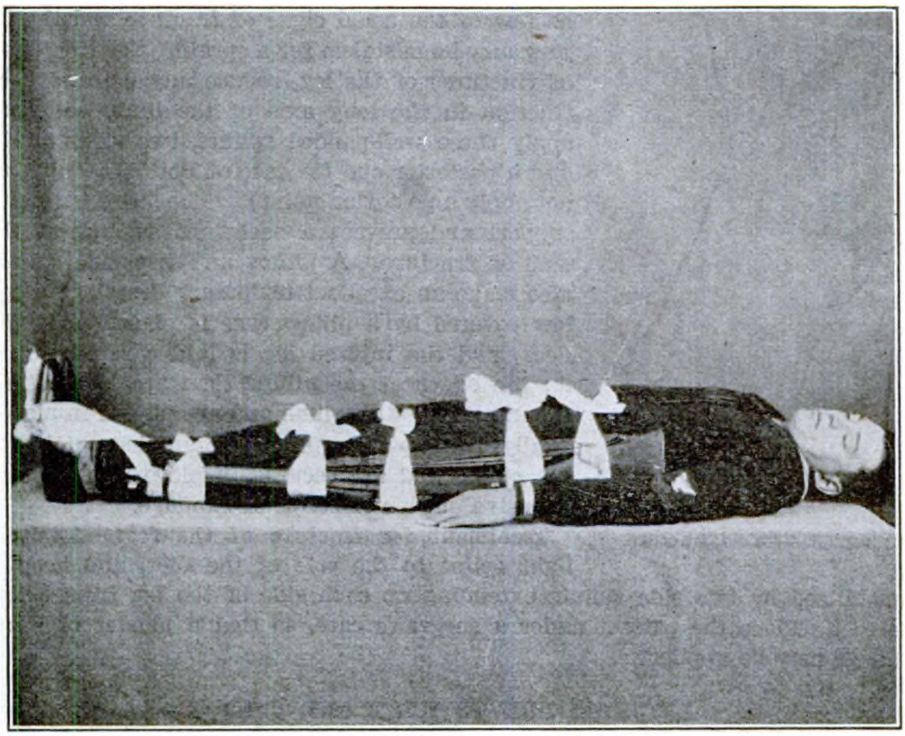


FIGURE 62.—Service rifle as emergency splint for fracture of femur.

patient must be brought under the care of a surgeon as soon as possible, as an anæsthetic is frequently necessary to effect reduction, and a traction splint or other means of extension is generally required. Do not move these cases without splinting.

Symptoms and treatment of fracture of the patella or knee cap.—In a fracture of the patella the patient cannot stand or walk, the upper fragment is drawn up to the thigh by the powerful muscle attached to it, and the gap can be felt readily; the joint swells up at once. Put the limb up straight with a well padded splint behind the thigh and leg. The two fragments can be brought together by strips of adhesive plaster, one strip passing above the upper fragment and the other below the lower one, or in place of the adhesive plaster a figure-of-eight bandage may be applied. The patient should be put to bed with the injured leg elevated on a pillow, and ice should be applied to the joint with the object of limiting and decreasing the swelling. Place the patient under the care of a surgeon as soon as possible.

Symptoms and treatment of fracture of the leg.—When both bones of the leg are broken, the usual signs and symptoms of fracture are present. These

fractures often are compound. If only one bone is broken, the other acts as a splint and deformity will not be so marked, but there will be present a local point of tenderness, swelling, and probably discoloration of the skin. Fracture of the lower end of the fibula is spoken of as *Pott's fracture* (fig. 63). Pott's fracture generally is accompanied by tearing of the internal lateral ligaments of the ankle joint or by a fracture of the internal malleolus, in which case there is great deformity and turning out (eversion) of the foot. In case it is purely a fracture of the lower end of the fibula, there may be few of the usual signs of fracture and the injury may be mistaken for a sprain. For treatment of fractures of the leg, reduce any deformity by traction in the long axis of the limb, and then apply three well-padded splints, two side splints, and a posterior one (in case of Pott's fracture, do not apply a posterior splint). The latter is to give support and prevent a backward sagging at the seat of fracture. A pillow and two side splints also make an excellent temporary dressing; a pillow covered by a pillow case is placed upon the deck, and the injured leg is laid carefully upon it; the edges of the pillow then are brought up around the foot and limb and are pinned in place; finally the two side splints are applied outside of the pillow and are secured in place by straps of adhesive plaster or strips of bandage.

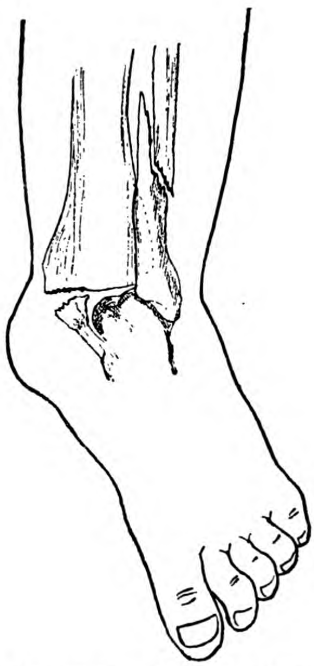


FIGURE 63.—Pott's fracture.

Treatment for fracture of the foot.—Apply a light splint to the sole of the foot, and keep it immobilized by two side splints extending up each side of the leg from below the foot. Place the patient under a surgeon's care, so that a plaster of Paris bandage may be applied.

INJURIES DUE TO HEAT AND COLD

Injuries due to heat are classified as *general* which embraces heat cramps, heat stroke (or sunstroke), and heat exhaustion, and *local* which includes burns and scalds.

Heat cramps are painful, spasmodic contractions of the muscles, usually those of the abdomen or of the extremities, and are caused by exposure to heat and to conditions causing muscular fatigue and loss of body fluids and salts. They may be considered the mildest form of generalized body injury from heat and their treatment is essentially the same as that for heat exhaustion.

Heat stroke (sunstroke or insolation) is due to prolonged exposure to excessive heat, usually to the heat of the sun. It may, however, occur in hot rooms, particularly in firerooms aboard ship. Exhaustion and improper clothing preventing the proper elimination of heat from the body surface are powerful contributing factors; hence this condition is especially apt to occur to men on the march, particularly when marching in close formation. The warning symptoms are headache, dizziness, irritability, frequent desire to urinate, and seeing things red or purplish. With or without these symptoms, the patient suddenly falls unconscious; the skin is dry and intensely hot; pupils contracted; pulse full and strong; respirations snoring; there may be convulsions; if the temperature of the body can be taken it usually will be found to be very high,

105° to 109° F., or higher. The condition is very serious, and unless immediately relieved terminates in death. The **treatment** has for its object the rapid reduction in temperature. The patient should be brought to the coolest accessible spot, in the shade, if out of doors; on deck if in the fireroom of a ship; the clothing removed; an ice bag applied to the head and cold water poured over the patient continually. At the same time the body may be rubbed with ice, and if a tub is available, immersed in cold water. The treatment should continue until the temperature is reduced. If the patient is able to swallow, cold, not iced, water should be given to drink, and this should be repeated as often as possible. Besides these measures for reducing the body temperature cool water to which table salt has been added, one-half teaspoonful to the glassful, should be given as freely as the patient will take it. In very severe cases, with the patient unconscious and unable to take fluid by mouth, give copious and frequent enemeta of 1,000 to 3,000 cc of cool, salt water, 1 teaspoonful of table salt per pint of water, every 30 minutes or hourly depending on the patient's response in recovering consciousness and on the drop in his body temperature. Serious results are liable to follow a sunstroke, even when death does not occur; the most common of these after effects are permanent headache, paralysis, mental confusion, or even insanity. Moreover, one who has had a sunstroke is ever after very susceptible to the action of the sun.

Heat exhaustion is due to the same causes that produce heat cramps and heat stroke. Under the same conditions, one man may get heat cramps, another heat stroke, and still another heat exhaustion. The warning symptoms are dizziness, often with nausea and vomiting associated in some instances, particularly in firerooms aboard ship, with cramps in the muscles. The patient suddenly falls; is not unconscious and may be easily aroused; temperature is subnormal; the face is pale, skin cool and moist; pupils dilated or normal; pulse very weak; respirations shallow, perhaps sighing; and perhaps one or several sets of muscles in painful contraction. In this condition of heat exhaustion certain muscles or groups of muscles frequently are thrown into violent contractions which cause excruciating pain. This condition is relieved by hot applications, immersion of the part of the person's body in a hot bath, or by the administration of an opiate (hypodermic injection of morphine). The **treatment** for heat exhaustion consists in moving the patient into the shade or on deck, loosening the clothing, keeping the head low, and giving him salt and stimulants; hot salt water or coffee to which one-half teaspoonful of table salt to each cupful or glassful has been added should be given freely. After removal to the sick-bay or hospital, the patient should be kept perfectly quiet in bed, with hot-water bottles and blankets around him if necessary.

The **prophylaxis** or prevention of heat cramps, heat stroke, and heat exhaustion is most important. It is now known that most of these general reactions to the effects of heat are due in great measure to the loss of body salts, chiefly sodium chloride, in the perspiration or sweat. A person perspiring freely for some time will not so readily taste salt in his drinking water which shows the loss of it in his body. Persons working in compartments in high temperatures, such as engine rooms and firerooms, especially in the tropics, should replace lost salt by taking ordinary table salt by mouth. One Navy sodium chloride tablet per glassful of water may be used, but in the absence of these tablets ordinary table salt should be taken freely under conditions where heat cramps, heat stroke, and heat exhaustion are likely to occur. The number of cases of heat cramps, heat stroke, and heat exhaustion can be reduced to a minimum by the adequate prophylactic use of sodium chloride in the drinking water.

Burns and scalds.—*Burns* are produced by flame, hot solids, hot fluids, caustics such as strong acids and strong alkalies, wires charged with a heavy electric current, sun's rays, and X-rays; *scalds* are produced by hot liquids. Burns and scalds differ only in that in the former the hairs are removed, whereas in the latter they are not; the treatment is the same for both. Burns usually are said to be of the first, second, and third degree; those which cause merely redness are of the *first degree;* if blisters are raised, they are of the *second degree;* if there is charring and destruction of tissue, the burn is of the *third degree.* The symptoms of burns are shock, which may be profound, chilly sensations, and pain; the pain may be agonizing or slight. The result of the burn depends more upon the extent of surface affected than upon its depth, a burn of the first degree being almost fatal if two thirds of the body surface be affected, and one of the second degree if one third of the body is burned. The chances of recovery are much less in children and elderly people. With extensive burns of the body surface, the danger in the first 24 hours is from shock, after that from internal congestion and inflammation, suppression of urine from nonfunctioning of the kidneys, ulcerations of the duodenum, intestinal hæmorrhage, and finally exhaustion or infection. If the entire thickness of the skin is destroyed, terrible deformities are apt to follow the contraction of the skin which follows healing. As the result of inhalation of live steam from bursted steam pipes, the respiratory tract may suffer from burns, causing death in many instances from suffocation or shock. X-ray burns are particularly slow in healing.

The **treatment** of burns is both *constitutional* and *local.* The constitutional treatment consists in the treatment of shock and pain, on the one hand, and, on the other hand, in measures to prevent suppression of urine, in combating the toxæmia and the effects of infection, etc. In addition to local measures for the treatment of pain, the administration of morphine, one-fourth grain, hypodermically, is frequently necessary. The bowels must be kept open, and plenty of water given by mouth, and also at times by rectum, so that the kidneys will continue to act. The smaller the area of body surface burned the less necessity there is for constitutional treatment. The object of the local treatment is to remove the cause, to allay pain, prevent infection, and promote healing. The deeper the burn, the more important do the methods for the prevention of infection become, and vice versa. The greatest factor in the causation of pain in burns is the movement of air over the inflamed area, and therefore local treatment in *first-degree* burns consists of covering the burned surface so that air is excluded. This may be done by means of tannic-acid jelly[1] dressings or by use of any fresh, bland oil, such as cream, vaseline, liquid petrolatum, olive oil, etc. If the burn has been caused by a caustic such as an acid or an alkali, the acid should be neutralized with bicarbonate of soda or ordinary baking soda, and the alkali by a weak solution of acetic acid or ordinary vinegar before the burned area is covered. In burns of the *second* and *third degree* the quickest temporary means of excluding air is to immerse the part or the entire body in warm water; then, having everything in readiness, carefully cut away the clothing, leaving such as may be sticking to the burned skin; blisters should be left undisturbed unless they are very tense and painful, when they may be punctured by a sterilized needle, and the content allowed to escape. The application of tannic-acid jelly dressings should then follow and the patient be put to

[1] Tannic-acid jelly is carried as an item on the Supplementary Supply Table and a good supply should always be kept on hand and available for immediate use.

bed. Later, the raw areas where the outer tissues have been destroyed may be treated by a freshly prepared 5 per cent aqueous solution of tannic acid applied either by an atomizer or by sterile cotton applicators. Several coats of the tannic acid solution are applied to all raw areas while an assistant fans the areas to promote the "tanning" process. The solution of tannic acid is useless for the treatment of first-degree burns in which the skin is intact for it will "tan" only raw areas. Following several repeated applications of the tannic acid solution the whole area is next treated with a 10 per cent silver nitrate solution applied with sterile cotton swabs. After the application of the silver nitrate solution, which is germicidal in its action and helps prevent infective organisms from growing beneath the "tanned" areas, a black pellicle of skin quickly forms beneath which new tissues grow and spread.

Whenever possible burns should first be treated by the tannic-acid method. (*See* formulas under Tannic Acid in section on Materia Medica.) In this method the tannic acid unites with and "tans" the tissues in the raw areas. When "tanning" is complete the burned areas have become dark-brown in color, and when they have dried they are covered with a hard, leathery crust of a dark-brown or black color. This crust: 1. Keeps the burned areas aseptic except when infected material has been covered over by it; 2. Lessens the possibility of infection as ordinarily infective organisms cannot penetrate through it; 3. Protects sensory-nerve endings from external stimuli and thereby lessens pain and suffering; 4. Prevents loss of water from the injured tissues and loss of body heat; and 5. Serves as a protective covering for the new tissues forming and growing to replace those which have been destroyed. Unless infection occurs beneath it the crust should not be disturbed until it begins to curl up at the edges and to peel off of its own accord, when the loosened parts may be cut away with sterile scissors.

The effectiveness of this method of treating burns is seriously interfered with if oils, ointments, or other greasy substances have previously been applied to the burned areas. Any oil, ointment, or grease that is present must be gently but thoroughly removed with sterile swabs and the area sponged with a weak solution of sodium bicarbonate before the tannic-acid treatment is begun, even though it may cause considerable suffering.

In rendering first aid at a fire the points to be kept in mind are: Prevent drafts from fanning the fire. Shut and keep shut all doors and windows. If one's own clothing catches afire, do not run, as this fans the flames; lie down on the deck or a bed and roll up as tightly as possible in a rug, shawl, overcoat, blanket, or other woolen cloth, leaving only the head out; if nothing can be obtained in which to wrap up in, lie down and roll over slowly, at the same time beating out the fire with the hands. If another person's clothing is on fire, throw him to the ground and smother the fire with a coat, blanket, rug, or the like; in doing this care should be taken to stand at the head, and, holding down with one foot one edge of the blanket or whatever is used, to throw it toward the feet of the individual; the flames thus are swept away from the rescuer and from the face of the burning person. Remember that the air within 6 inches of the deck is free from smoke, so when unable to breathe a rescuer should crawl along the floor with the head low, dragging anyone who has been rescued behind him. The rescuer should tie a wet handkerchief or cloth over the mouth and nose to minimize the danger of suffocation.

Cold or chilling.—Injuries due to cold are classified as *general*, or constitutional, not *local*.

Prolonged exposure to extreme cold results in a general depression or lowering of the vitality, a gradual chilling of the body, and a congestion of the internal

organs. The body and limbs first feel numb and heavy, and then become stiff; drowsiness and an irresistible desire to sleep take hold of the individual. If left alone, unconsciousness rapidly follows. When found in such a condition, life not yet being extinct, a person should be taken into a cold room, all clothing removed, and the body rubbed briskly with sheets or towels wet with cold water. As soon as the stiffness is removed artificial respiration should be performed; and when the patient is able to swallow, warm drinks should be given. When there are signs of returning consciousness and circulation the body may be enveloped in a blanket and the temperature of the room gradually raised. The reason why a frozen person must not be removed to a warm room is that the sudden restoration of the circulation gives rise to violent congestions and often to sudden death from the formation of clots in the blood vessels.

In intense cold, **frostbite** not infrequently occurs without one's knowing it, but usually the ears, fingers, etc., become painfully cold, and then one suddenly realizes that no longer is there any feeling in the parts. The color of the frozen part is white or grayish white. The object of treatment is to bring the frozen part *gradually* to its normal temperature. The danger of sudden thawing is congestion and bursting of the capillary walls which have been weakened by freezing, and resulting in gangrene or death of the part; therefore the patient should not go into a warm room or near a fire. Rub the part vigorously with wet snow or ice water; never with dry snow, as the temperature of the dry snow may be much below freezing and rubbing with it would aggravate the condition. When the pain and redness return use warm water gradually. *Chilblain* is a condition of acute or chronic congestion occurring especially in the feet and due to bringing cold feet near the fire too suddenly or merely following exposure to cold in persons with poor circulation. On the part affected are red spots, more or less swollen, which burn and itch intensely. The treatment consists in stimulating applications, such as liniments and tincture of iodine. Susceptible persons should wear woolen socks.

REMOVAL OF FOREIGN BODIES

Either *inanimate objects* such as splinters, cinders, marbles, peas, beans, etc., or *animate objects* such as insects, maggots, ticks, etc., may gain access to the tissues and cavities of the body. With regard to the removal of inanimate foreign bodies, if their removal is difficult or liable to be attended with much damage to the tissues, the patient should be brought under the care of a surgeon as soon as possible for the removal of the foreign body. If the services of a medical officer are not to be had for some time, then the first-aid man must be guided by the probable relative benefit to the patient of having him wait the required time for expert treatment or of doing the operation himself. The main principle to be kept in mind in the removal of an inanimate foreign body is to avoid infecting the tissues, by using sterile appliances, and to do as little damage to the tissues as possible. The main principle underlying the treatment of conditions where insects, etc., have gained access to tissues and cavities of the body is to kill the object first and then remove it. Creatures such as insects and ticks are best killed by putting some bland oil, such as olive oil or liquid petrolatum, into the cavity to which they have gained access, the oil covering over their breathing pores and thus suffocating them, after which they usually may be easily washed out.

Foreign bodies in the eye.—Foreign bodies, such as particles of dust, cinders, etc., may lodge under the lids, upon the conjunctiva, or upon the cornea. In

the latter situation they are seen and removed with the greatest difficulty, and the removal ordinarily should not be attempted by other than a medical officer. To remove a foreign body from the eye one end of a wooden applicator should be wrapped with cotton and dipped in boric acid solution, and then drawn lightly across the eyeball or eyelid with a wiping movement. Never attempt to lift off or dig out a foreign body from the eye. Probably the best improvised article for removing a foreign body from the eye, and one that nearly always is at hand, is a match, which may be used in the same way as a wooden applicator, the plain end being covered with cotton or with a clean handkerchief. Or, the match may be lighted, allowed to burn a moment, and the flame blown out; then, with a clean handkerchief and a rolling movement of the fingers twist off the charred end which leaves a soft, clean, splinterless surface with which to wipe away the foreign body. *To examine the lower lid,* draw it down with the fingers, at the same time having the patient look up; if the foreign body is not found there, *evert the upper lid* by standing behind the patient with the head upon your chest, and telling the patient to look down; at the same time press a match or the end of the finger firmly against the outside of the lid about a quarter of an inch behind its margin. Draw the lid down by the lashes, and turn it upward and outward over the match or finger tip. If the particle still is not visible, search the ball of the eye carefully for it, and when it is found, lift it off gently by a quick movement with the point of the match. If the eye is very irritable, it may be necessary to put in a few drops of 2 per cent cocaine solution. It is important to remember that even after a foreign body is removed from the eye there is often for some time a sensation as if it were still there. After removing a foreign body the eye should be irrigated with boric acid solution and a few drops of 5 to 10 per cent silvol solution instilled.

Foreign bodies in the ear.—The foreign body may be an insect, a pea, a grain of wheat, a pebble, a plug of hardened wax, etc. An insect in the ear by its movements and buzzing often causes the most intense annoyance. Hold the head over on one side with the ear containing the insect uppermost; drop in 5 or 10 drops of bland oil, such as olive oil or liquid petrolatum, and then syringe the ear; or fill the canal with water which will cause the insect to float to the surface from where it can easily be removed. If the foreign body is vegetable, such as a pea, water should not be used, as it may cause the pea to swell and thereby render its extraction more difficult. If the pea is visible, bend the loop of a fine hairpin and try to get beyond it so as to hook it out. As there is always danger of injuring the eardrum when instruments are pressed into the ear, it should be a guiding rule that no instrument should be passed beyond the point where its tip can be seen. *Hardened wax* may be softened with a few drops of hydrogen peroxide, then removed by syringing with a warm 5 per cent solution of soda.

Foreign bodies in the nose.—Children and insane persons often push peas and other foreign bodies into the nose, and occasionally flies deposit their eggs there with the result that maggots develop in the nasal cavity. Foreign bodies are best removed by closing the free nostril with the finger and forcibly blowing through the obstructed side; snuffing a little powdered tobacco or pepper will cause sneezing and aid in the expulsion; if this does not succeed and the body can be seen, it may be hooked out with a bent hairpin in the same manner as described for the ear. Should these measures fail to remove the foreign body it should be left alone until the patient can be brought to a medical officer. The presence of maggots in the nose is a very serious condition, which

may result in death. Let the patient inhale through the nose a half teaspoonful of chloroform, and while the maggots are stupefied syringe them out with warm physiological salt solution.

Foreign bodies in the throat.—Foreign bodies in the throat are usually bones or masses of food. If the bone can be seen and reached, it may be removed by fingers or forceps; if not, it may be carried down by eating dry bread. If the obstruction is a mass of food, it may be dislodged by forcible blows on the back between the shoulders or the fingers may be passed into the throat to hook it out or to cause its ejection by vomiting. Foreign bodies in the air passages cause violent coughing and difficult breathing; the case is urgent, and in the case of a child, he may be held up by his heels and shaken; if an adult, inversion also may be attempted and the case treated as described for foreign body in the throat.

Foreign bodies in the stomach.—Foreign bodies sometimes are swallowed and reach the stomach and intestine. Such cases are not usually serious. If the body is angular or pointed, such as a tack or pin, feed the patient on substances which leave considerable residue to cover and protect the sharp points—potatoes, bananas, bread, etc. Do not give laxatives, as they will render the bowel movements liquid and thus leave sharp points exposed and because the increased peristalsis favors injury to the intestinal walls. The patient should, however, be brought under the care of a surgeon.

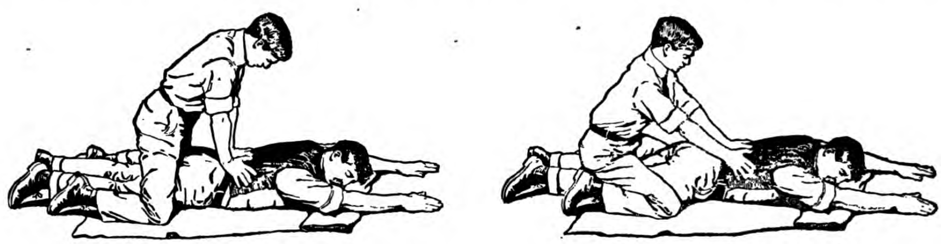
Foreign bodies in the skin.—Here are found splinters, thorns, needles, pins, fishhooks, pieces of glass, gunpowder, etc. For splinters and thorns pass the point of the blade of a pocketknife under them; with the thumb-nail press the splinter against the blade and draw it out; or use a pointed dissecting or dressing forceps. If the splinter is buried, open up the skin a little with the point of a knife or a needle until it can be reached; if under a nail, cut a notch in the nail so as to expose it. If a needle or a pin is broken off in the skin and cannot be grasped with forceps, cut a small hole in the end of a cork and press it down over the point of entrance of the needle; this may cause the needle to emerge so far that it can be grasped. The needle may be so situated that it is best to push it through and extract it on the other side. If the needle or pin is in the foot or the hand and cannot be extracted, the patient should be directed not to use the part, as muscular action will cause it to work in deeper. A fishhook or an arrow cannot be drawn out on account of the barbs; they must be pushed through. Gunpowder is removed best by a thorough scrubbing with soft soap and a stiff brush, the remaining grains being picked out with a needle.

ASPHYXIA

Asphyxia is a condition where respiration, or breathing, has ceased. It may be the result of either abnormal physiological or physical causes. When due to the latter it may be spoken of as suffocation. Among the physiological causes of asphyxia are: Lack of stimulation of the respiratory center in the medulla oblongata, paralysis of the respiratory center, and inability of the blood to absorb oxygen from the lungs or to effect the normal exchange of gases in the body tissues. In asphyxia resulting from physical causes the lungs are deprived of air because of stoppage of the air passages mechanically, as by water in drowning, by a foreign body, by a diphtheritic membrane extending into the larynx, by a tumor, by swelling of the mucous membranes following inhalation of live steam or an irritating gas, by a constricting band around the neck compressing the trachea; or because of the presence or irrespirable gases in the air.

The **treatment** is to first remove the cause or remove the patient from the cause, then give artificial respiration, and later treat for shock.

Artificial respiration.—There are several accepted methods of applying artificial respiration but the best and probably the least dangerous is the *prone pressure* or *Schaefer's, method* (fig. 64). No reliance should be placed upon



Expiration; pressure on. Inspiration; pressure off.

FIGURE 64.—Prone pressure or Schaefer's method of artificial respiration. (Keen.)

any special mechanical apparatus, as it is frequently out of order and often is not available when most needed. The prone pressure method of artificial respiration is as follows: Lay the patient face downward on a blanket or clothing spread out flat with the head turned to one side. The arm on the side toward which the face is turned is extended beyond the head, the other is bent at the elbow and the hand or forearm placed beneath the head. The operator kneels astride of both or of one of the patient's thighs, facing toward the head and places the palms of his hands on the lower part of the thorax, the little fingers touching the lowest ribs and the ends of the fingers just out of sight. (If only one thigh is straddled it should be the one on the side toward which the patient's face is turned so that his face can be easily observed.) Then, keeping the arms straight, the operator swings his body slowly forward, causing the hands to press upward and inward. This compresses the abdomen and the lower part of the thorax, forces out the air in the lungs and produces an expiration. At the end of the forward swing the operator's shoulders should be directly above the heels of his hands. Hold the pressure momentarily and then quickly remove it by swinging backward to the original position, which permits the thorax to expand and produces inspiration. After a wait of a couple of seconds swing forward again. The alternate compression and release movements together should take about 4 or 5 seconds and should be repeated rhythmically 12 to 15 times a minute. As an aid in timing the movements the operator may repeat the following words to himself: "Forward slow, hold it, swing back, wait a second."

In swinging backward the operator's hands should be removed from the patient, and he should adjust his position so that he can easily maintain his balance during the movements. The patient's mouth should be cleared of any obstruction such as chewing gum or tobacco, false teeth, or mucus so that there is no interference with the entrance and escape of air. To keep the patient warm during artificial respiration is most important and it may be necessary to cover him with blankets and work through them, as well as to apply hot-water bottles, hot bricks, etc.

Artificial respiration may be required in those persons apparently drowned; asphyxiated by gases, fumes, or noxious vapors, and anæsthetics; electric shock; shock or collapse; freezing or exposure to extremes of heat or cold; cases of poisoning, etc.; in other words, in all cases in which breathing is temporarily suspended. The symptoms by which the necessity for artificial

respiration may be recognized are: Cyanosis (blueness of the skin and membranes); suspension of respiration; or shallow breathing in some cases of poisoning. Artificial respiration should be continued for at least 4 hours without interruption or until the patient is pronounced dead by a medical officer.

Treatment for a person apparently drowned.—Every minute and second counts, so waste no time. Have bystanders move away to give the victim all the air possible. Loosen clothing about neck, chest, and abdomen. With handkerchief or towel in hand, gently swab out the mouth and throat to remove mud or mucus. Turn the patient over, face downward, place the hands under the abdomen, one on either side, and lift the patient, in an endeavor to drain the lungs and stomach, then with a large roll of clothing under the abdomen, and by making firm pressure upon the loins, continue the efforts to expel the water from the lungs and stomach. If the individual then does not breathe, proceed immediately with artificial respiration. It is well at the same time to try to stimulate respiration by having an assistant hold ammonia or smelling salts to the nostrils. Recovery from drowning has occurred where persons have been submerged for some minutes; the statements of observers as to length of time of immersion can never be accepted, as in emergencies of this sort minutes seem like hours. When breathing has been reestablished, remove wet clothing and treat the shock.

Treatment for a person asphyxiated by hanging or by strangulation.—Promptly remove any constriction from the neck and also clothing from around the chest. Attempt to excite breathing by dashing cold water on the face and body; if this fails, proceed with artificial respiration.

Treatment for a person asphyxiated by choking.—The choking may be due to a foreign body or to such a thing as a diphtheritic membrane. Make an attempt to remove the offending material as described in a previous paragraph.

In many of these cases it will be necessary to do a tracheotomy, that is, cut a hole in the windpipe, or in diphtheritic cases, to do either an intubation or a tracheotomy. This, however, must be done by a surgeon and no time whatsoever must be lost in bringing the patient under his care. After removal of the obstructing material, perform artificial respiration in the manner described previously.

Treatment for asphyxiation from poisonous gases.—Illuminating gas and the exhaust gases from gasoline engines are the most common causes of gas poisoning. It is the carbon monoxide in these gases which is responsible for the damage. When carbon monoxide is in sufficient concentration in the air being breathed it forms a stable compound with the hæmoglobin of the blood; this prevents the hæmoglobin from taking up oxygen and carrying it to the tissues. The patient must be removed as soon as possible into the fresh air and artificial respiration instituted. In the meantime send for a medical officer, as it often becomes necessary to let out some of the patient's blood and substitute therefor good blood from some one else (*transfusion*). A person poisoned with carbon monoxide presents a cherry-red appearance on cheeks and lips.

UNCONSCIOUSNESS

Insensibility and unconsciousness are one and the same thing. There are varying degrees of unconsciousness, and the same agent causing partial unconsciousness, if further applied, may cause total unconsciousness. There are numerous causes for unconsciousness, and in order to properly treat it the cause must be discovered. To treat a case of unconsciousness is one of the most difficult things that may fall to the lot of the first-aid man. In all

cases of unconsciousness strenuous efforts should be made to bring the patient under the care of a medical officer as soon as possible. To ascertain the cause of unconsciousness, the first-aid man should be very observant of the surroundings as well as of any evidence on the person of the patient which might give a clue to the cause. If there are any observers on the ground or any who are acquainted with the patient's habits and past history, all information possible should be obtained from them. The patient's body should be examined for evidences of injury, bleeding, or paralysis. It should be noted whether the skin is moist and cold, or hot and dry. The character of the respirations should be noted, whether deep, strong, and fast, or whether weak, shallow, and slow. It should be noted whether the pulse is weak and shallow, or whether it is bounding and strong. The condition of the pupils should be noted; whether they are even or uneven, dilated or contracted. The breath should be smelled for evidence of alcohol, and a note made whether there is frothing at the mouth or injury to the tongue. The common causes for unconsciousness are asphyxiation, bleeding, shock, electric shock, heat exhaustion, freezing, sunstroke, epilepsy or fits, apoplexy and injury to the brain (concussion and compression), alcoholism and certain other poisons, hysteria, and uræmia. For the symptoms and treatment of suffocation, bleeding, shock, heat exhaustion, sunstroke, and freezing, see previous paragraphs.

Electric shock is caused by coming in contact with a "live wire"; spasmodic contraction of the muscles occurs so that the person cannot let go. Depending on the strength of the current in the wires in contact with the patient, sudden death or insensibility, with or without severe burns, may be caused. The first thing to be done is to rescue the patient by setting him free from the wire, and this must be done with great care, as to touch him with bare hands will cause the rescuer to get the same shock. With a single quick motion, free the victim from the current. Use any *dry nonconductor* (clothing, rope, board) to move either the victim or the wire. Beware of using metal or any moist material. While freeing the victim from the live wire have every effort also made to shut off the current quickly. Immediately start artificial respiration, and when voluntary breathing returns, treat for shock. The burns must be treated as other burns. Lightning stroke causes similar symptoms to the foregoing and the treatment is the same.

Epilepsy or **fits.**—In epilepsy there may be fits with insensibility, or a mere momentary unconsciousness with slight muscular twitching, but in which the patient does not fall. In the severe form, with or without warning signs, the person suddenly cries out in a peculiar manner and falls in a fit; at first the entire body is rigid, then there are general convulsions with jerking of the limbs, contortion of the face, and foaming at the mouth. After a few minutes the convulsions are followed by profound stupor, and this generally passes off into a deep sleep. During the attack the eyeballs may be touched without the patient flinching, the pupils are dilated, the patient often bites his tongue, and there may be involuntary evacuations of the bowels and bladder. Epileptic unconsciousness may be distinguished from other forms by the history of the fit, and of other previous fits, by the foam at the mouth and the bitten tongue and by the absence of any paralysis. As far as **treatment** goes, nothing can be done to stop the fit or to control it; all that can be done is to prevent the patient from hurting himself and to make him as comfortable as possible; do not attempt to hold him, but twist a handkerchief, passing it between his jaws, and tie it at the back of the neck until after the fit is over to keep him from biting his tongue. After the fit is over let the patient sleep as long as he will. One must be on the

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lookout in the service for men feigning epileptic fits in order to obtain a discharge. The feigned attacks usually occur at night when no one can see them; the man does not fall so as to hurt himself, does not bite his tongue, flinches when the eyeball is touched, the pupils are not dilated and the patient can be aroused. When there is foaming at the mouth a piece of soap often will be found inside the mouth. A pail of cold water suddenly thrown upon the man's head and shoulders usually makes the diagnosis; it promptly revives the malingerer, but has little or no effect on the epileptic.

Concussion of the brain.—Concussion of the brain is a condition present when a man has been "knocked senseless" or "stunned." It is a jarring and shaking of the brain due to blows or falls upon the head or falls upon the feet; the brain almost stops working for a time. The symptoms are unconsciousness, pallor of the face, breathing so quiet and shallow that it hardly can be detected, pulse fluttering, pupils equal and usually contracted. The degree of insensibility varies. Sometimes the patient can be aroused, but is irritable, and lapses again into unconsciousness which may last minutes or hours. Vomiting and turning on the side are favorable symptoms. The treatment consists in perfect rest in a dark, quiet room; warmth applied externally if the surface is cold; and aromatic spirit of ammonia by inhalation if there is much depression.

Compression of the brain and apoplexy.—Compression of the brain is, as the term implies, a pressure on the brain. This pressure is due usually to either a piece of bone or to a hæmorrhage from a torn vessel within the cranium, and as the blood cannot leave the cranial cavity it compresses the brain. This compression prevents certain parts of the brain from working. When the bleeding is the result of injury the condition is called *compression of the brain*; when it is the result of the bursting of a diseased blood vessel without any violence it is called *apoplexy;* the result and the symptoms are practically the same. The symptoms of compression are profound unconsciousness; loud, snoring breathing; slow pulse; pupils usually unequal and not reacting to light; and usually paralysis on one side of the body. If the compression is due to a piece of broken bone, the symptoms come immediately after the injury, while if it is due to bleeding they may come on later and gradually. The treatment of both compression and apoplexy consists of keeping the patient absolutely quiet, at rest in a comfortable position, and applying cold applications to the head during the acute stage. *Do not administer stimulants.* When convalescent, regulate diet, recommend a very moderate amount of exercise, and instruct the patient to avoid worry and excitement.

Hysterical unconsciousness.—Hysteria is a disease of the nervous system accompanied by loss of control over the emotions. It usually is seen in women, but also may be present in nervous men. The disease is manifested in a great variety of ways, but the only form that will be mentioned here will be that accompanied by convulsions. In this form hysteria may closely resemble epilepsy. The patient usually has an attack of laughing and crying and gradually "works himself up" to such an extent that he falls in a convulsion. The attacks sometimes are prolonged for several hours, and upon recovery, it is not uncommon to find the patient laughing or sobbing for some time after. He appears to be unconscious, but in falling he always picks out some soft spot or chair to fall upon, and is careful not to injure himself. The tongue rarely is bitten in hysteria. Hysteria may be mistaken for epilepsy, but in the latter condition the fall is sudden, and the sufferer frequently receives painful scalp wounds or injuries to the tongue. While hysteria is a disease, the patient nevertheless should be treated with firm-

ness. The subjects usually crave sympathy. To sympathize with such a patient is the worst possible thing one can do and simply prolongs the attack or hastens another. The best thing to do is to leave the patient alone —of course seeing that no harm can come to him. When he recovers and finds himself alone and without sympathy it is not likely that he will repeat the attacks. In prolonged convulsions, throwing water in the face usually will terminate the seizure.

Uræmia or the insensibility of Bright's disease.—The insensibility of Bright's disease is really an acute poisoning from the retention of the waste products which the diseased kidneys are not able to eliminate. The unconsciousness often is attended with delirium and convulsions. The pupils are contracted, the pulse is slow, there is a peculiar odor of the breath, and the breathing is loud and snoring. The distinguishing characteristics are the history of Bright's disease, the waxy color of the skin, sometimes dropsy, abnormal urine (albumin, casts, etc.), and ordinarily the absence of paralysis. Emergency treatment consists in applying cold cloths to the head and a hot mustard poultice to the back over the kidneys. If the services of a medical officer are not available within a brief period of time, catheterize, and give an enema and a hot pack.

Unconsciousness caused by acute alcoholism.—The use of alcohol, if carried to excess, produces a condition of unconsciousness which is very likely to be confounded with other similar conditions. Too great care cannot be taken in examining these cases thoroughly, as mistakes are of frequent occurrence, and cases of fractured skull or apoplexy often are pronounced mere alcoholism. Do not be led astray by the fact that a person has an odor of liquor about him. He may have been drinking and had a stroke of apoplexy, or may in falling have fractured his skull. If there is the least doubt, it is better to give the patient the benefit than to run any risks. A person suffering from alcoholic coma lies in a stupor, but usually can be partially aroused and made to answer questions. The face is flushed, the pulse is first full and rapid then feeble and slow, and the respirations are deep. The pupils usually are dilated and the breath has the heavy odor of alcohol. Ordinary intoxication rarely requires any treatment besides rest and sleep. If the patient is in an exhausted state, it is well to wash out the stomach, then cover him warmly and apply heat to the extremities. If coma is present, try to arouse the patient by cold douching or striking with wet towels. If the pulse is weak, stimulants should be given; inhalations of ammonia and the internal use of strychnine or caffeine may be employed if the patient is conscious. The use of strong coffee by the rectum is often of great service.

When unable to diagnose exactly the cause of unconsciousness determine, if possible, that it is due neither to a poison, to bleeding, nor to sunstroke, for each of these demands immediate special treatment, nor to suffocation, for which it would be necessary, of course, to give artificial respiration. Then, unless it is necessary to give the special treatment, if the patient is pale and weak, have him lie down with his head low, apply warmth and stimulate him in every way possible; on the contrary, if the face is red and pulse is very strong, while the position for the patient should also be lying down, the head should be raised. No stimulants should be given in the latter condition, and cold water should be sprinkled on the face and chest.

After a patient has been taken to the sick bay or the hospital Bogan's test to determine the amount of alcohol per cubic centimeter of circulating blood or in the urine may be used in doubtful cases of unconsciousness where alcoholism is suspected, but this test does not rule out poisoning, head injury, etc., which can and frequently *do* accompany alcoholism.

ACUTE ABDOMINAL CONDITIONS

The most common, serious, acute abdominal conditions are *acute appendicitis, perforating ulcers of the stomach or duodenum, intestinal obstruction, gall-stone colic, kidney-stone colic,* and *poisoning by infected food* or *by other poisons.* Pain and tenderness in the abdomen, general or localized or both, nausea and vomiting, and more or less shock are symptoms common to these conditions. Beginning pneumonia, lead poisoning (painters' colic), and inflammation of the testicle are conditions outside of the abdomen which may produce similar symptoms. Acute indigestion and constipation are comparatively mild conditions which may be confused with these conditions.

Many cases of acute appendicitis, obstruction of the bowels, and acute pancreatitis that have been diagnosed as acute indigestion or constipation have resulted in the death of the patient. All cases presenting symptoms of abdominal pain or nausea and vomiting, particularly when associated with more or less shock, should be brought under the care of a medical officer as soon as possible, as time is a very important element in averting a fatal end in many of these conditions.

One always should suspect something more than ordinary indigestion or constipation if there is much prostration, shock, or elevated temperature, or *if the symptoms persist for any length of time.* Many a person suffering from acute appendicitis or obstruction of the bowels will ascribe the condition to something that has been eaten, but do not be deceived by such a statement. Get all the information possible as to how the attack started, history of previous attacks, and symptoms prior to the present attack, whether the patient has vomited blood or not, and when the bowels last moved; take the temperature and pulse rate; lay the patient flat with the abdomen bared and determine by gentle and careful palpation where the pain and tenderness are most marked. Make a white blood count if possible.

Acute appendicitis.—Appendicitis is an inflammation of the appendix. A patient frequently complains for several days before the attack of indigestion, loss of appetite, constipation or diarrhœa, and uneasiness in the abdomen, or the attack may come on suddenly. The pain may start in the pit of the stomach, then become generalized over the abdomen, and finally, after several hours, become localized in the right lower quadrant of the abdomen with marked tenderness on pressure and rigidity of muscles over that point. Vomiting generally comes on 3 or 4 hours after the beginning of the attack. The temperature may be subnormal from mild shock or be elevated to 100° or 101° F. There is generally an increase in white blood cells to above 10,000 per cubic millimeter. In acute appendicitis the appendix becomes full of pus and the danger lies in its rupture with resulting peritonitis. Many cases never rupture, whereas others often rupture in 3 or 4 hours after the attack starts. The object is to remove the appendix before its rupture, as otherwise death may ensue from peritonitis, or the abdomen may have to be drained for months with or without final recovery and perhaps resulting in the formation of adhesions, making the patient more or less a permanent invalid. The **treatment** consists in placing the patient under the care of a surgeon as soon as possible. In the meantime put to bed, giving nothing by mouth, not even hot water; give a soap and water enema very low and under very little pressure, and put a hot-water bag over the appendix. Do not use an ice bag. In case no medical officer is available for some time, liquids in small amounts may be given after 48 hours. *Never give a cathartic to a person suspected of having acute appendicitis.*

Acute intestinal obstruction.—In this condition, a loop of bowel becomes constricted, resulting in the inability of the intestinal contents to move beyond the point of constriction and cutting off the blood supply to the loop of the bowel with resulting gangrene or death to the bowel. This condition is followed by absorption of poisons from the intestine, peritonitis, and death if the condition is not relieved. Two very common ways for the bowel to become constricted are by means of adhesions within the abdomen and by a loop of bowel becoming strangulated in a hernia, or rupture, as it is commonly called. The symptoms are inability to pass gas or fæces by the rectum, pain in the abdomen, vomiting becoming more and more frequent, and intense shock. The abdomen may be distended above the point of constriction and be flat below that point. There is generally a leucocytosis as in appendicitis. The loop of bowel must be relieved of its constriction or death will ensue. Place the patient under the care of a surgeon at the earliest possible moment. In the meantime, take the following measures: 1. If the obstruction is due to a strangulated hernia, and the case has not gone too far, put the patient in a hot tub with the buttocks elevated in order to relax the inguinal ring, and exert gentle pressure over the tumor; 2. Put the patient to bed, give a soap and water enema, and nothing by mouth. *Never give a person suspected of suffering from obstruction of the bowels a purgative.*

Perforated gastric or duodenal ulcer.—Generally, though not always, a person suffering from perforated ulcer of the stomach or duodenum gives a long history of stomach trouble. Acute pain "in the pit of the stomach," associated with more or less shock, is suddenly felt. The pain is sudden and intensely violent, which is greatly increased by swallowing fluids, by vomiting, by turning the body, by coughing, by respiration, and by pressure. This pain may radiate throughout the abdomen, but the chief tenderness is in the region of the stomach. Vomiting occurs in about one-half the cases at the time of perforation. Shock may be severe following the perforation, but, as a rule, does not last long. A board-like rigidity of the muscles of the abdomen is present, and the temperature is usually normal or subnormal. The danger from perforated ulcer of the stomach or duodenum is peritonitis, due to the escape of stomach or duodenal contents into the peritoneal cavity. The **treatment** consists in bringing the patient under the care of a surgeon as soon as possible before peritonitis sets in; in the meantime, put the patient to bed, *give absolutely nothing by mouth*, and put an ice bag over the stomach; and treat shock and hæmorrhage if present.

Gall-stone colic.—Gall-stone colic is due to the passage, or the attempt at passage, of a gall-stone from the gall bladder to the intestines. Depending on the location of the stones, a person with gall-stones may or may not be jaundiced. The patient frequently gives a history of stomach trouble with or without jaundice and may give a history of previous gall-stone colic. The colic consists of spasmodic, excruciating pain over the stomach and liver, radiating upward over the right half of the thorax, frequently up under the right shoulder blade. The patient is very nauseated, and usually vomits, and often the vomiting is violent. The abdomen is distended and a condition of collapse soon comes on. The respirations are shallow, the patient groans, cries out, or flings about the bed, often assuming strange contorted positions, trying to obtain relief, frequently holding one hand over the liver region. The pain is one of the most excruciating a human being can experience. The usual duration of an attack is from 4 to 20 hours, although it may last much longer. The temperature is usually normal or subnormal. The patient should be brought under the care of a medical officer as soon as possible. If one is not

at hand, give one-fourth grain of morphine hypodermically, followed in an hour by another one-fourth grain, and place a hot-water bag over the liver at the lower border of the ribs.

Kidney-stone colic.—This condition is due to a small stone from the kidney entering into the ureter, which it blocks, tears, or distends. The pain is gradual or sudden in onset, is fearful in intensity, and runs from the lumbar region down the corresponding thigh and testicle and into the abdomen and back. There are nausea, vomiting, collapse, and sometimes unconsciousness or convulsions. Frequent attempts at urination result in pain but little urine. The urine is often smoky or red from injury to the ureter. After a time the pain vanishes, due to the stone falling back into the pelvis of the kidney or to its passing on into the bladder. **Treatment** consists of bringing the patient under the care of a medical officer, and, in the meantime, putting to bed, giving plenty of water by mouth to increase the flow of urine, putting a hot-water bag on the affected side of the abdomen, and, if necessary, giving morphine, one-fourth grain hypodermically.

Poisoning causing acute abdominal symptoms.—If the condition is due to eating infected foods containing toxins or harmful breakdown products formed by the action of bacteria on the food it is probable that more than one person will apply for treatment. The symptoms are vomiting, diarrhœa (at times bloody), fever, abdominal cramps, and sometimes considerable prostration. In the absence of a medical officer, clear out the intestine with a good dose of castor oil. If a severe case occurs, put the patient to bed, give a purge, and allow nothing by mouth except plenty of water, until symptoms abate, then increase diet gradually. Should severe constipation be present an enema of soap and water may be given.

In case the acute abdominal symptoms are due to **inflammation of the testicles,** there usually will be a history of urethral infection, or mumps, or injury to the testicle, and on examination the part will be seen to be tender and swollen. **Lead poisoning** may resemble in its symptoms any acute abdominal condition mentioned, particularly acute intestinal obstruction and appendicitis; in this case, however, there is a history of working with lead, paint, or in compartments laden with lead paint chippings; the so-called "blue line" at the margin of the gums most likely will be present, and a blood smear stained with Wright's stain will show stippled red cells and probably anæmia. In case the symptoms are due to a beginning pneumonia, there usually will be a history of chills a short time before, the respiration will be increased with a rising fever, and perhaps a beginning cough with sputum. There is generally a high leucocytosis, even up to 30,000.

The main principles a first-aid man should remember when treating a case with acute abdominal symptoms are: 1. No purgative should be given when appendicitis or intestinal obstruction is suspected; 2. The time elapsing before surgical aid can be obtained is of the greatest importance for the future welfare of the patient; 3. No morphine or opium should be given for pain except in frank cases of gall-stone and kidney-stone colic, as this will mask the symptoms for the surgeon when he arrives.

SOME COMMON EMERGENCY SYMPTOMS

Fever is a name given to a group of symptoms consisting of a rise of temperature above normal (98.6° F.), with attendant increase in the pulse rate and a rise in the number of respirations per minute; associated with which are generally headache and flushing of the face, a feeling of weakness, irritability,

and loss of appetite. Fever is simply a group of symptoms and is not a disease in itself. Fever is one of the main symptoms of all infectious diseases and infections and for some time may be the only evidence of an infection or an infectious disease. It may, however, simply be due to the results of constipation, with absorption of poisonous products from the intestine, but as a rule the temperature in these cases does not go above 101° F. **In handling a fever case**, if possible bring the patient under the care of a medical officer. The problem in a case of fever is to find the cause if possible. Get the history of the case, how long there has been fever, what other symptoms have been or are present; if there has been exposure to an acute infectious disease, or constipation; and examine the throat and skin for evidences of the cause. If no other symptoms are present but an acute fever, which is not very high, and if the patient is not particularly sick, a good purgative probably will give relief. Do not load up the patient with drugs. Constipation with fever is spoken of as **autointoxication.** If the patient has a high fever and is sick, give a brisk purgative, put to bed on a liquid diet, and put an ice bag on the head. In the meantime try to obtain the services of a medical officer and watch the patient carefully for symptoms which will point the way to ascertaining the cause of his fever. In case the beginning of an infectious disease is suspected the patient, of course, should be isolated.

A cold.—The term "cold" is applied to a group of symptoms consisting of a running at the nose, lacrimation (overflow of tears), and fever, generally with headache and malaise (opposite of well-being). These symptoms may be due to a so-called common cold or they may be forerunners of such infectious diseases as influenza, measles, infantile paralysis, or cerebrospinal fever. If the patient is quite sick, fever high, and depression is marked, particularly if there has been exposure to the above-mentioned infectious diseases, suspect that it is something more than a common cold, and, if possible, place the patient under the care of a medical officer. Find out whether the patient has been recently exposed to such diseases, and by questions and examination ascertain whether further symptoms are present which may lead to a diagnosis. Give the patient a brisk purgative; isolate, and keep on the lookout for further symptoms. If the case is one of common cold, a brisk purgative should be given early, the patient advised to drink plenty of water, and hot drinks given at night, possibly with 10 grains of aspirin, or Dover's powder, to stimulate perspiration.

Headache.—Headache may be due to a great variety of causes. It is a constant accompaniment of fever, of acute infectious diseases, of autointoxication, and of head injuries. It frequently is due to eye strain. In all cases of headache it is well always to take the temperature and to inquire into the condition of the patient's bowels. There must be a cause, and the problem is to find it. Do not try to cure headaches with drugs without trying to find out the cause, except perhaps in emergency 10 grains of aspirin may be given after a good purgative. Patients with frequent headaches should always consult a medical officer when available.

Diarrhœa.—Diarrhœa is a term applied to a condition characterized by the passage of frequent, watery stools. It may be due to diseases such as dysentery, meat or other poisoning, typhoid or other fever, or simply to the presence in the intestine of some irritating material from fermentation and putrefaction. Always take the temperature of a person suffering from diarrhœa; question and examine for any other symptoms present or for information able to be given. All cases of severe or continued diarrhœa should be brought

under the care of a medical officer. In case the diarrhœa is due to overeating, with consequent absorption of the products of intestinal putrefaction, administer a brisk cathartic to get rid of the offending material.

Hiccough.—Hiccough usually is due to overeating and indigestion. It is caused by spasmodic contractions of the diaphragm, the great muscle which separates the chest from the abdomen. This is the reason that holding the breath as long as possible usually will cure this condition, as the air in the chest forces the diaphragm down so that it does not contract. Drinking a large glass of water in small sips while holding the breath has exactly the same effect. A sudden fright occasionally stops a hiccough, because it causes the patient to take a long breath. If none of these methods are successful, removal of the irritating material from the stomach by vomiting almost always will cure the hiccough. It may, however, be due to some constitutional disease, such as Bright's disease, and persistent cases should be brought under the care of a medical officer.

Convulsions.—Convulsions are most commonly due to epilepsy, hysteria, and various kinds of poisoning. The **treatment** consists in summoning a medical officer, keeping the patient from biting the tongue or inflicting other injury, and finding out all one can to ascertain the cause.

Earache.—Earache may be due to a diseased molar tooth, to beginning mumps, to a stoppage of the Eustachian tube from an inflammation of the throat, and from inflammation or abscess of the external auditory canal, of the ear drum or of the middle ear. In treating examine the teeth and if there is a molar tooth diseased on the affected side, treat it as described in the section on Emergency Dental Treatment. Examine the throat, and if it is inflamed treat it as described under Sore Throat. Examine for beginning mumps by feeling back of the angle of the jaw for tenderness and swelling and put a very little diluted acetic acid on the back of the tongue to see whether it causes pain and aching in that locality. Pull the ear upward and backward and see if there is swelling and redness in the external auditory canal; if so, the earache is due to inflammation there or in the middle ear. Inflammation of the middle ear is dangerous, owing to the possibility of extension of the process into the mastoid cells and from there to the brain unless prompt surgical attention is given. If the earache is due to inflammation of the middle ear, get the patient under the care of a surgeon as soon as possible, as the ear drum probably will have to be incised. In the meantime, for inflammation of the external auditory canal or middle ear, put the patient to bed with hot applications or a hot-water bottle on the affected ear.

Chills.—Chills may be simply the result of overexposure to cold and wet, or may be the forerunner of pneumonia, or part of an attack of malarial fever or other disease. Always watch the patient with a chill for other symptoms during and after the chills. The immediate **treatment** consists of putting the patient in bed between hot blankets, using hot-water bags, and giving hot drinks.

Sore throat.—Sore throat may be one of the symptoms in quite a large number of diseases, particularly ordinary tonsillitis, diphtheria, scarlet fever, Vincent's infection, and syphilis. Always have these diseases in mind in a case of sore throat, and never fail to examine the throat thoroughly in all cases. If a membrane is present in the throat, the case may be one of ordinary tonsillitis, of diphtheria, or of scarlet fever. If ulcers are present on the throat, syphilis may be the cause. A good treatment for an ordinary sore throat is to give a brisk cathartic, have the patient gargle his throat

every hour with Dobell's solution or diluted vinegar. When possible, always make a smear and stain from the throat of a case of tonsillitis and examine for diphtheria organisms. When in doubt about a case, isolate it and bring it under the care of a medical officer as soon as possible.

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Section 2.—BANDAGES AND BANDAGING

Bandages are employed to hold dressings applied to the surface of the body, to secure splints in the treatment of fractures and dislocations, to create pressure, to immobilize joints, and to correct deformity.

Various materials are employed in making bandages, such as gauze, flannel, crinoline, muslin, linen, rubber, and elastic webbing. Gauze frequently is used because it is light, soft, thin, porous, readily adjusted and easily applied. Flannel, being soft and elastic, may be applied smoothly and evenly, and as it absorbs moisture and maintains body heat, is very useful for certain conditions. Crinoline, rather than gauze, is used in making plaster of Paris bandages, as the mesh of the crinoline holds the plaster more satisfactorily than gauze. Muslin is employed in making bandages because it is inexpensive and readily obtainable. It should be soaked in water to cause shrinkage, dried, and finally ironed to remove wrinkles. A large piece of this material easily may be torn into strips of the desired width.

Rubber and elastic webbing are used to afford firm support to a part. The webbing is preferable to the pure rubber bandage, as it permits the evaporation of moisture.

It is of the greatest importance that a hospital corpsman should become familiar with the general rules of bandaging and proficient in the application of the various types of bandages. The comfort of a patient, the security of the dressing, and the professional reputation of hospital corpsmen depend upon the proper application of a bandage. A neatly and properly applied bandage is an indication that the dressing covered by the bandage has been properly performed. An untidy, uncomfortable, insecure, improperly applied bandage reasonably may lead one to suspect that the underlying dressing is of the same character and can result only in adverse criticism.

Various types of bandages, commonly used, are the roller bandage, the triangular bandage, and the many-tailed bandage.

The roller bandage is made from one of the afore-mentioned materials, the width and length depending upon the part to be bandaged. For convenience and ease of application, the strip of material is rolled into the form of a cylinder. Each bandage of this type should consist of only one piece, free from wrinkles, seams, selvage, and any imperfections that may cause discomfort to the patient. Although there are various types of mechanical appliances used in winding bandages, it is essential that hospital corpsmen should be able to roll a bandage by hand.

The strips of bandage material should be folded at one extremity several times to form a small, firm cylinder. This cylinder is held by its extremities with the index finger and thumb of the left hand. The free end of the bandage is held between the index finger and thumb of the right hand, close to the

cylinder. With this hand the bandage then is revolved around the cylinder, which is held in the left hand, the free fingers of which aid in turning the cylindrical roll. The amount of tension exerted upon the free end will determine the firmness of the completed roller. A roller bandage consists of the free end or initial extremity, the body, and the terminal extremity in the center of the cylinder.

The length and width of bandages vary according to the purposes for which they are employed. The sizes most frequently used are: 1 inch wide, 3 yards long, for the hand, fingers, and toes; 2 inches wide, 6 yards long, for head bandages; 2½ inches wide, 7 yards long, for extremities; 3 inches wide, 9 yards long, for thigh, groin, and trunk.

GENERAL RULES FOR BANDAGING

In applying a roller bandage the roll should be held in the right hand so that the loose end is on the bottom; the *outside* surface of the loose or initial end is next applied to and held on the part by the left hand; and the roll is then passed around the part by the right hand, which controls the tension and application of the bandage. Two or three of the initial turns of a roller bandage should over-lie each other in order to secure the bandage and keep it in place. In applying the turns of the bandage it is often necessary to transfer the roll from one hand to the other.

Bandages should be applied evenly, firmly, and not too tightly. Excessive pressure may cause interference with the circulation and may lead to disastrous consequences. In bandaging an extremity it is therefore advisable to leave the fingers or toes exposed in order that the circulation of these parts may be readily observed. It is likewise safer to apply a large number of turns of a bandage rather than to depend upon a few too-firmly-applied turns to secure a splint or dressing.

In applying a wet bandage, or one that may become wet in holding a wet dressing in place, it is necessary to allow for shrinkage. The turns of a bandage should completely cover the skin, as any uncovered areas of skin may become pinched between the turns, with resulting discomfort.

Bandages should be applied in such a manner that skin surfaces are not brought in contact, as perspiration will cause excoriation and maceration of the skin.

In bandaging an extremity it is advisable to include the whole member (arm and hand, leg and foot), excepting the fingers and toes, in order that uniform pressure may be maintained throughout. It is also desirable in bandaging a limb that the part be placed in the position it will occupy when the dressing is finally completed, as variations in flexion or extension of the part will cause changes in the pressure of certain parts of the bandage.

The initial turns of a bandage of an extremity (including spica bandages of the hip and shoulder) always should be applied securely, and, when possible, around the part of the limb that has the smallest circumference. Thus in bandaging the arm or hand the initial turns usually are applied around the wrist, and in bandaging the leg or foot the initial turns are applied immediately above the ankle.

The final turns of a completed bandage usually are secured in the same manner as are the initial turns, by the employment of two or more overlying circular turns. As both edges of the final circular turn are necessarily exposed, they should be folded under to present a neat, cufflike appearance. The terminal end of the completed bandage is turned under and secured to the final turns by either a safety pin or adhesive tape. When these are not avail-

able, the end of the bandage may be split lengthwise for several inches, and the two resulting tails secured around the part by tying.

When the turns of a bandage cross each other, as in the figure-of-eight, the spiral reverse, and the spica, the line of crossings should be straight, and if practicable, should be in the center line of the part bandaged, but the line of crossings should not be over a bony prominence. The exposed portions of the turns should be of approximately the same width.

In removing a bandage, it may be cut, preferably with bandage scissors. In doing so the operator should be careful to avoid interference with the underlying dressing and the affected area.

If the bandage is removed without cutting, its folds should be gathered up in first one hand and then the other as the bandage is unwound. This procedure will facilitate removal and the rewinding of the bandage, if that be desirable.

APPLICATION OF BANDAGES AND THEIR USES

Circular bandage.—After anchoring the initial turns of the bandage, as described in a previous paragraph, a series of circular turns is made around the part. Each turn should overlie accurately the turn beneath it, neither ascending nor descending. Uses: Retention of dressings to a limited portion of an extremity, the neck, or the head; compression to control venous hæmorrhage and to promote venous stasis.

Spiral bandage.—After anchoring the initial turns, each turn is applied in a spiral direction in such a manner as to overlie one-third of the preceding turn. As usually applied to an extremity the upper edge of each turn of an ascending spiral is tighter than the lower edge with resulting inequality of pressure. For this reason many surgeons object to its use on an extremity. However, this apparent fault may be overcome to a great extent by applying the bandage in the manner described in a preceding paragraph. Uses: Retention of dressings of the arm, chest, and abdomen (fig. 65).

FIGURE 65.—Spiral bandage. (Owen.)

Oblique bandage.—A series of oblique turns is applied around a part in such a manner as to have an uncovered area between turns. The width of the uncovered area should be uniform throughout. Uses: Retention of thick dressings or of temporary dressings which require frequent removal.

Recurrent bandage.—In applying this bandage, the roller, after securing the primary turns, is carried completely over a part to a point opposite its origin, and then reflected and brought back to the starting point, where it is secured by one or more circular turns (fig. 66).

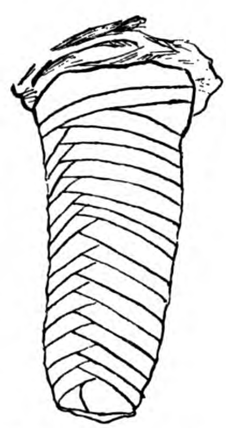

FIGURE 66.—Recurrent bandage of stump. (Wharton.)

In the recurrent bandage of the hand, the bandage is secured at the wrist, carried over the back of the hand, around the tips of the fingers, across the palm to the wrist. Held at this point by the disengaged hand of the operator, the bandage is carried across the palm around the tips of the fingers, across the back of the hand to the wrist, where it is held by the thumb of the operator's disengaged hand. Each turn overlies one-third of the preceding turn.

The original turn over the fingers may cover the middle and ring fingers, with each succeeding turn applied alternately over the other fingers first to one side and then to the other of the middle finger; or the original turn over the fingers may be applied over the first finger or over the little finger, each subsequent turn covering a portion of the remaining exposed fingers. The reflected portion of the bandage at the wrist is then secured by a number of circular turns. It is customary to complete such a bandage with a figure-of-eight bandage enclosing the entire hand.

Figure-of-eight bandage.—This is undoubtedly the most useful bandage and with its various modifications, probably is employed more frequently than any other bandage. The hospital corpsman should perfect himself in the application of this bandage, as, with a few exceptions, the majority of bandages are applied on the principle of the figure-of-eight. Its name is derived from the fact that the turns are applied so as to form a figure 8. Although it is employed commonly in bandages of the joints (elbow, knee, and ankle), it frequently is applied in bandaging the neck and axilla, the head and neck, and the head and jaw (Barton). If properly applied, it may be used very successfully in bandaging the extremities.

Figure-of-eight of hand and wrist.—After anchoring the bandage with two circular turns about the wrist the bandage is carried across the back of the hand to the base of the fingers, then into the palm, across the palm to the back of the hand, and across the back of the hand to the starting point at the wrist, where one circular turn is made. This general course is followed with several similar turns, each one overlying about one-third of the preceding turn on the back of the hand. After a sufficient number of turns has been made, the bandage is terminated with a circular turn around the wrist. Uses: Retention of dressings on the back of the hand or in the palm (fig. 67).

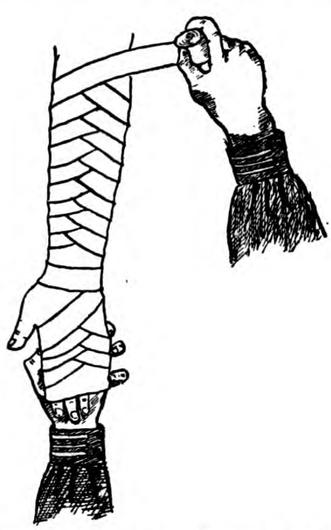

FIGURE 67.—Figure-of-eight bandage. (Wharton, modified.)

Figure-of-eight of forearm.—This bandage may be the continuation of the figure-of-eight of the wrist and hand, or may be started with primary circular turns of the wrist. The bandage is carried obliquely upward across the back of the forearm and around the arm in its natural course, where it forms the upper loop of the figure-of-eight. The bandage then is carried in an oblique direction downward, across the back of the arm, where it crosses the upward turn of the bandage. Then it is carried around the lower end of the forearm to complete the lower loop of the figure-of-eight. The same process is repeated several times until the elbow is reached, each turn overlapping the upper one-half or three-quarters of the preceding turn. The bandage is terminated finally with two or more circular turns at the elbow. The final circular turn, with both upper and lower edges of the bandage folded under, should be applied firmly and should present a neat cufflike appearance at the upper end of the completed bandage (fig. 67).

During the application of this bandage there is always considerable slack in one edge of the bandage where it is carried around the arm. As the bandaging proceeds, however, these loose edges are covered by the ascending turns of the bandage. Uses: Retention of dressings and covering of splints.

Spiral reverse bandage of the arm.—This bandage is in reality a modification of the figure-of-eight, in that only the lower loop or one-half of the figure-of-eight is completed. After anchoring the primary turns, the bandage is carried obliquely upward on the back of the arm. When this turn reaches the center line of the arm, the thumb of the disengaged (usually the left) hand is placed upon the body of the bandage to hold it securely in place upon the arm. The operator then unrolls about 5 or 6 inches of bandage which is held slack and is folded upon itself by changing the position of the hand holding the roller from supination to pronation. The bandage then is carried obliquely downward across the arm to a point opposite that from which the ascending turn started. It then is tightened slightly to conform to the part accurately, then is carried around the limb and the procedure is repeated. It is necessary to retain the thumb upon the point of reverse until the succeeding turn reaches that point. As in the figure-of-eight, each turn should overlie at least one-third of the preceding turn, and the reverses should be in a straight line (fig. 68).

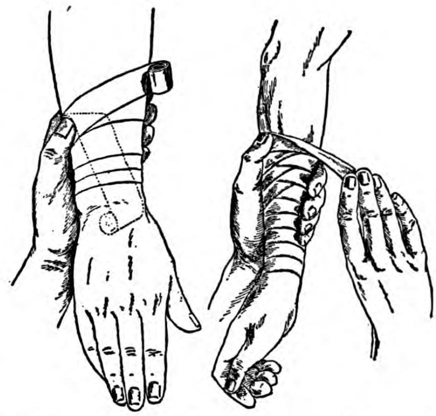

FIGURE 68.—Spiral reverse. (Eliason.)

Complete bandage of the hand.—After securing the initial turns around the wrist, a recurrent bandage of the hand is applied. The bandage then is carried obliquely across the back of the hand to the tip of the index finger. A circular turn is made around the ends of the fingers. The fingers and hand then are covered by a figure-of-eight or spiral reverse bandage, which finally is completed by two or more circular turns around the wrist. This bandage may or may not be applied to include the thumb. Uses: Retention of dressings of the hand (fig. 69).

FIGURE 69.—Complete bandage of hand. (Wharton.)

FIGURE 70.—Demigaunlet of hand. (Wharton.)

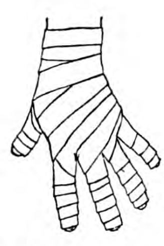

FIGURE 71.—Gauntlet bandage of hand. (Wharton.)

Demigauntlet bandage.—Using a 1-inch bandage, secure the initial turns at the wrist and carry the bandage across the back of the hand to the base of the thumb, around the thumb, across the back of the hand to the wrist, where a circular turn is made. The same procedure is repeated successively for each finger and the bandage finally terminated with a circular turn around the wrist. Uses: Retention of dressings on back of hand (fig. 70).

Gauntlet bandage.—The demigauntlet bandage may be extended to include the entire thumb and fingers with either simple spiral turns or spiral reverse turns of each digit (fig. 71).

Figure-of-eight bandage of the elbow.—With the elbow in the desired position, the initial end is secured by circular turns around the forearm just below the elbow. The bandage then is carried upward over the flexure of the elbow

in an oblique direction and passed around the arm just above the elbow, where a circular turn is made, and then is carried obliquely downward across the flexure and passed around the forearm. This procedure is repeated, with each turn overlying the preceding turn, the turns on the forearm ascending and those on the arm descending until the entire joint is covered. The final turn is a circular one around the elbow joint itself. This bandage may be started with a circular turn around the joint followed by figure-of-eight turns covering the upper part of the forearm and the lower part of the arm. Uses: Retention of dressings around the elbow joint.

Spica bandage of right shoulder (ascending).—After securing the initial end by two circular turns around the arm opposite the axillary fold, the bandage is carried diagonally across the arm and front of the chest to the axilla of the opposite side, then around the back of the chest, across the arm, and across the upward turn to the point of origin. After carrying the bandage around the arm, this procedure is repeated, each turn overlying about two-thirds of the preceding turn until the entire shoulder is covered. The turn should cross in a straight line extending up the center line of the arm over the point of the shoulder. Likewise the turns across the chest and back should overlap each other uniformly, and the turns in the opposite axilla should overlap each other exactly. The bandage may be secured by either a pin or adhesive tape. Uses: Retention of dressings of shoulder and axilla and of shoulder cap (fig. 72).

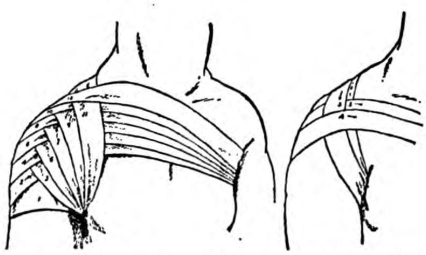

FIGURE 72.—Spica of the shoulder. Spica loops of the shoulder. (Eliason.)

Bandages of the lower extremity.—The bandages described in the preceding paragraphs may be applied to the corresponding parts of the lower extremity. However, a description of a few of the special bandages of the lower extremity is considered advisable.

Spica bandage of the groin (ascending).—After securing the initial turns around the upper part of the thigh just below the groin, the bandage is carried obliquely upward across the lower abdomen to the iliac crest of the opposite side, transversely across the back and then downward obliquely across the front of the thigh, across the upward turn of the bandage and around the thigh to the point of origin, thus completing a figure-of-eight. This is repeated several times until the entire groin is covered, each turn overlying about two-thirds of the preceding turn. The same care in regard to the line of crossings of the turns and to the uniform overlapping of the bandage on the abdomen should be observed, as is noted in the description of the spica bandage of the shoulder. Uses: Retention of dressings in region of the groin (fig. 73).

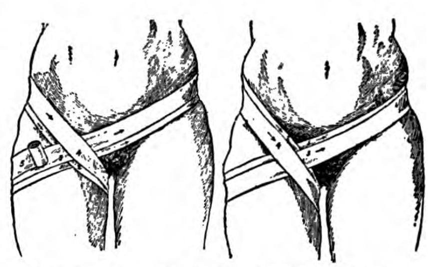

FIGURE 73.—Ascending spica; descending spica. (Eliason.)

Spica bandage of the foot.—The initial end is secured by two circular turns around the leg just above the ankle. The bandage then is carried across the dorsum of the foot to the base of the toes where a circular turn is made around the foot. After two or three spiral reverse turns are made the bandage is carried across the dorsum of the foot, backward alongside of the

heel, around the heel, forward along the other side of the heel across the preceding upward turn on the dorsum of the foot, and around the foot to the starting point of the turn. This process is repeated, the turns gradually ascending on both the foot and the heel, the crossings of bandage being in the midline of the dorsum of the foot. The bandage finally is carried upward around the ankle and secured by two or more circular turns at its original starting point. It is possible to apply this bandage without the use of the spiral reverse turns by employing the figure-of-eight throughout. Uses: Retention of dressings on the foot and support for sprained ankle (fig. 74).

Bandage of foot, not covering the heel (French).—After securing the initial end by two circular turns around the leg just above the ankle the bandage is carried obliquely across the dorsum of the foot to the base of the toes, where a circular turn is made around the foot. The bandage is carried up the foot by a few spiral reverse turns crossings in the center line, and then applied as a figure-of-eight around the ankle and instep. The bandage may be terminated just above the ankle or be extended up the leg as far as may be necessary. It is frequently practicable to apply this bandage without employing the spiral reverse turns, the figures-of-eight being applied following the circular turns at the base of the toes. Uses: Retention of dressings of foot. This bandage usually is employed in application of bandages covering the entire leg.

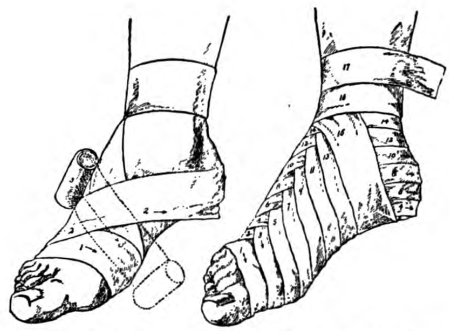

FIGURE 74.—Spica of the foot (first step); spica of the foot (completed). (Eliason.)

Special bandages.

Velpeau bandage.—The fingers of the affected side are placed upon the opposite shoulder, a pad placed in the axilla, and the skin surfaces separated by sheet wadding. Place the initial end of the bandage on the shoulder blade of the sound side, carry the bandage across the outer portion of the affected shoulder, downward over the outer and posterior surface of the flexed arm, behind the point of the elbow, obliquely across the back of the forearm and chest to the opposite axilla, and around to the point of origin. After repeating this turn once the bandage is carried from the point of origin across the back and side of chest, in front of the flexed elbow and transversely across the front of the chest. Then it is carried around the other side of the chest, diagonally across the back to the affected shoulder. The first turn then is repeated, followed by a second circular turn around the chest and flexed arm. Each vertical turn over the shoulder overlaps two-thirds of the preceding turn, ascending from the outer part of the shoulder to the neck and from the upper posterior surface of the arm inward toward the point of the elbow. Each transverse turn also overlies one-third of the preceding turn. These transverse turns are continued until the last turn covers the wrist.

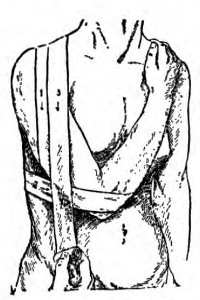

FIGURE 75.—Velpeau (start). (Eliason.)

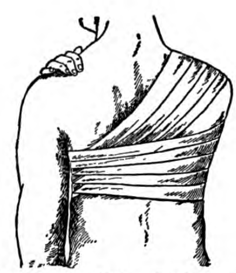

FIGURE 76.—Velpeau (posterior view). (Eliason.)

The bandage is finally secured with pins, both where it ends and at various points where the turns of the bandage cross each other. (The initial turns of this bandage may be secured by circular turns around the chest under the arm of the affected side.) Uses: Fixation of arm in treatment of fractured clavicle and fixation of humerus after reduction of dislocated shoulder joint (figs. 75, 76, 77).

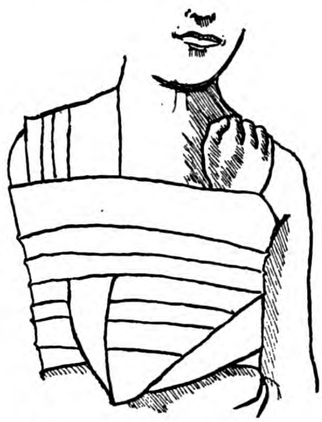

FIGURE 77.—Velpeau bandage. (Wharton.)

Barton bandage.—With the initial end of the bandage applied to the head just behind the right mastoid process the bandage is carried under the bony prominence at the back of the head, upward and forward back of the left ear, obliquely across the top of the head, downward in front of the right ear, under the chin, upward in front of left ear, obliquely across the top of the head, crossing the first turn in the midline of the head, thence backward and downward to the point of origin behind the right mastoid. Then it is carried around the back of the head under the left ear, around the front of the chin, under the right ear to the point of origin. This procedure is repeated several times, each turn exactly overlying the preceding turn. The bandage is secured with a pin or strip of adhesive tape, and either a pin or adhesive may be applied at the crossing on top of the head. Uses: Fracture of lower jaw; retention of dressings of chin (fig. 78).

FIGURE 78.—Barton bandage. (Wharton.)

Recurrent bandage of head.—The initial turns are applied around the head, passing around the nape of the neck, above each ear and around the forehead. When the bandage has reached the center of the forehead on the third turn, its free margin is held by a finger of the left hand and the bandage is reversed and carried over the top of the head in the center line to the nape of the neck. With an assistant holding the bandage at the latter point, it is reflected forward over the top of the head covering the right half of the preceding turn. When it reaches the forehead in the midline it again is reflected over the top of the head, overlying the left half of the first turn. At the nape of the neck in the center line it is again reflected and carried forward overlying the outer half of the second turn. This process is repeated until the entire head is covered, the turns alternating to the right and left of the center line. The bandage finally is completed by several circular turns overlying the original turns and fixing the ends of antero-posterior turns at the nape of the neck and on the forehead, where pins should be applied to provide additional security. Uses: Retention of dressings of wounds of the scalp, of fractures and operative wounds of the skull (fig. 79). (This bandage may be applied with the turns over the head in a transverse direction extending from ear to ear.

FIGURE 79.—Recurrent turns. (Eliason.)

Crossed bandage of one eye.—The initial extremity is secured by a circular turn around the head below the bony prominence at the back, above both ears and across the forehead. The bandage then is carried from the back of the head, below the ear, obliquely across the outer part of the cheek to the base of the nose at its junction with the forehead, over the opposite side of the head and downward behind the mastoid process. A circular turn then is carried around the head, overlying exactly the original turns. A second turn under the ear and across the face and head then is applied, overlapping the upper two-thirds of the preceding turn. These alternating turns are repeated until the eye (and if more comfortable, the ear on the same side) is completely covered. The bandage is completed with a final circular turn around the head. Uses: Retention of dressings of the eye (fig. 80).

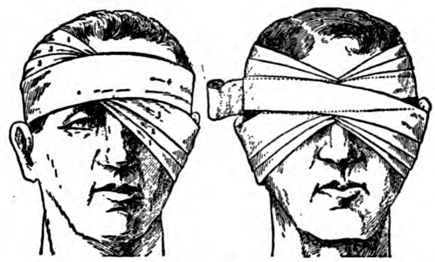

FIGURE 80.—Crossed bandage (figure-of-eight) of the eye; crossed bandage of both eyes. (Eliason.)

Crossed bandage of both eyes.—The initial turns are applied as for one eye, and the bandage carried forward below the right ear, diagonally upward across the cheek to the base of the nose and over the opposite side of the head above the left ear, and downward behind the left mastoid process. Then a circular turn is applied. When the roller reaches the back of the head below the bony prominence it is carried obliquely forward and slightly upward over the right ear across the forehead and downward over the left eye, the lower margin of the bandage crossing the previous turn at the junction of the nose with the forehead. The bandage then is carried across the left cheek below the left ear and backward to the nape of the neck. Then a circular turn is made, followed by a repetition of the previous turns across the eyes, each circular turn accurately covering its predecessor and each oblique turn overlying the upper one-half of the preceding turn, until both eyes are completely covered. The ears may or may not be included in the bandage, which is completed by two circular turns around the head. Pins are placed at the intersections of the bandage (fig. 80).

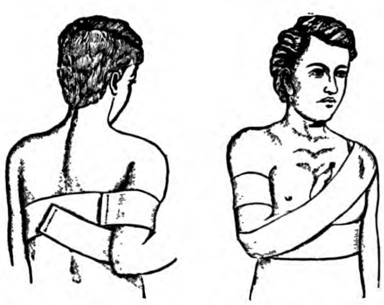

FIGURE 81.—Sayre's dressing for fracture of the clavicle, showing application of first and second strips. (Wharton.)

Sayre's dressing.—This consists of two strips of adhesive plaster 3 inches wide and 2 yards long. Two circular turns of a flannel bandage 4 inches wide are applied to the arm of the affected side just below the axillary fold. The end of one adhesive strip is looped around the arm (overlying the flannel bandage) and pinned, with the loop sufficiently large not to constrict the arm. With the arm drawn upward and backward, the strip of plaster is carried across the back and around the opposite side of the chest. It may end here or be carried completely around the chest. The hand of the injured side now is placed as near as possible to the shoulder of the sound side, the skin surfaces being separated by sheet wadding. The end of the second strip is applied over the scapula of the affected side (some surgeons start this strip at the top of the posterior surface of the arm of the affected side;

others apply the initial end of this strip on the shoulder of the sound side) and is carried downward on the posterior surface of the arm of the affected side, under the point of the elbow, diagonally across the chest on the posterior surface of the forearm and hand over the sound shoulder down the back where it joins the first strip of plaster. A small hole is cut in this strip to receive the point of the elbow, which must be protected by a layer of cotton or sheet wadding. Then the entire dressing is covered with a Velpeau bandage. Uses: Treatment of fractures of the clavicle (fig. 81).

"T" bandage.—This bandage consists of a horizontal bandage to which is attached, about its middle, a vertical bandage of approximately one-half the length of the horizontal bandage. The horizontal portion is employed to secure the bandage to the body, the vertical portion being used to retain dressings. This bandage is very useful in retaining dressings about the perineum and anal region. When used for this purpose, the horizontal band is applied around the abdomen above the iliac crests, in such a manner that the vertical portion is placed exactly in the midline of the back directly over the spine. The vertical portion then is brought forward between the thighs and secured to the horizontal portion in front of the abdomen. The vertical portion may be split longitudinally to form two strips of equal width.

Double "T" bandage.—This differs from the foregoing in having two vertical strips instead of only one. The horizontal portion may be of any desired width. It frequently is used for the retention of dressings of the chest, breast, and abdomen. When so employed the two vertical strips are carried over the shoulders from the back to the front and secured by pins to the horizontal portion.

Many-tailed bandage.—The four-tailed bandage readily is made by splitting a strip of muslin or other material of the desired width, lengthwise, within a few inches of the center of the strip. This provides a bandage with a body and four tails.

The many-tailed bandage is prepared in a similar manner, by splitting the muslin or other material into several strips, having a sufficiently large area in the center for the retention of dressings, etc. The number of tails on each side should be the same.

Plaster of Paris bandage.—These bandages are prepared by impregnating the meshes of crinoline with plaster of Paris of the extra calcined, dental variety, A strip of crinoline about 3 or 4 inches wide, and usually 4 or 5 yards long, is placed on a table. Plaster of Paris then is dusted upon the strip, and evenly rubbed into the meshes of the fabric. A very satisfactory method of preparing this bandage is by constructing a wooden box, 12 inches long, 6 inches wide, and 3 inches deep, and at each end, just above the bottom of the box, cutting a slit 5 inches long and one-eighth to one-fourth inch wide. The end of the bandage is drawn into the box through one slit, across the bottom of the box, and out of the box through the other slit. A sufficient quantity of the plaster of Paris to cover the bandage with a layer of powder 1 inch deep is placed in the box. As the bandage is drawn through plaster of Paris is rubbed into the meshes with the hand or preferably with a smooth piece of wood approximately 4 inches in length. The bandage may be loosely rolled into a cylinder as it emerges from the box. If the bandages are not to be used within a few hours they should be wrapped in paper to prevent absorption of moisture.

Application of the plaster of Paris bandage.—The part to be encased in plaster of Paris should be covered with a suitable bandage of soft material, preferably flannel. The bony prominences should be well protected with cotton. Care should be taken to remove all creases in the dressing and bandage.

Two rolls of the plaster of Paris bandage are placed in warm water. When bubbles cease to arise from the bandage one roll is removed from the water, the excess water being expressed by grasping the roll at its two ends and exerting pressure with the hands. This method prevents the loss of a considerable amount of plaster through the ends of the roll. (*Note.*—As soon as a bandage is removed from the water replace it with another bandage.)

The bandage should be applied rapidly and evenly to the limb. No special form of bandage is necessary as it is sufficient that the part be properly covered. The second bandage is applied as soon as the first has been completed. During the application of the bandage it should be rubbed with the hands in order to provide a smooth even surface. It also is desirable to rub some loose plaster into the dressing. When the final roller has been applied the surface of the completed dressing should be rubbed evenly with liquid plaster prepared by addition of water to dry plaster until it has the consistency of thick cream.

In many cases, such as compound fractures, it is frequently necessary to provide access to certain areas of the encased limb. After the bandage has partially set a "window" or trap may be cut in the bandage over the desired area.

Removal of a plaster of Paris bandage may be accomplished with the aid of a plaster saw. If none is available the plaster may be softened with a small amount of peroxide of hydrogen, hydrochloric acid, or vinegar, and then may be cut with a knife.

Uses: Fixation of fractures; ambulant treatment of fractures; fixation and treatment of injuries and diseases of joints.

Starched bandage.—This bandage may be obtained already prepared or it may be prepared in the following manner: Starch is mixed with cold water until a thin, creamy mixture results. This is heated to form a clear mucilaginous liquid. The part should be covered with a flannel bandage over which a gauze bandage is applied. The starch then is rubbed evenly into the meshes of the material. A second gauze bandage is applied and again treated with the starch mixture. This may be repeated until the desired thickness of the bandage is obtained.

Bandages impregnated with starch may be moistened and applied wet to a part. This type of bandage is occasionally useful in the treatment of sprains of the thumb or fingers.

Triangular bandage.—This bandage, also known as the handkerchief bandage, is used for the temporary or permanent dressing of wounds, fractures, dislocations, etc., and for slings. It is very valuable in first-aid work as it is quickly and easily applied, stays on well, and can be improvised from any kind of cloth, as a piece of a shirt, an old sheet, a large handkerchief such as the Navy-uniform neckerchief, etc. Unbleached muslin is generally used in making triangular bandages although linen, woolen, silk, etc., will answer the purpose. In making them a square of material about 3 by 3 feet or slightly more is folded diagonally to make one bandage or may be cut along the fold to make two bandages. The long side of the triangle is called the *base*, the point opposite the base is called the *apex*, and the points at each end of the base are called the *ends* or *extremities*. These bandages may be used either as a triangle or as a cravat, the latter being made from the triangle by bringing the apex to the base and folding it upon itself a sufficient number of times to obtain the width desired (fig. 82). The names of these bandages indicate the part of the body to which the base is applied, the location of the apex, and the shape. For example, in the *fronto-occipital triangle* the base of a triangular bandage is

applied to the forehead and the apex is carried to the occiput, and in the *mento-vertico-occipital* cravat the middle of the base is placed under the chin and the ends carried over the vertex of the skull to the occiput. A few of the more commonly used triangular bandages will now be described.

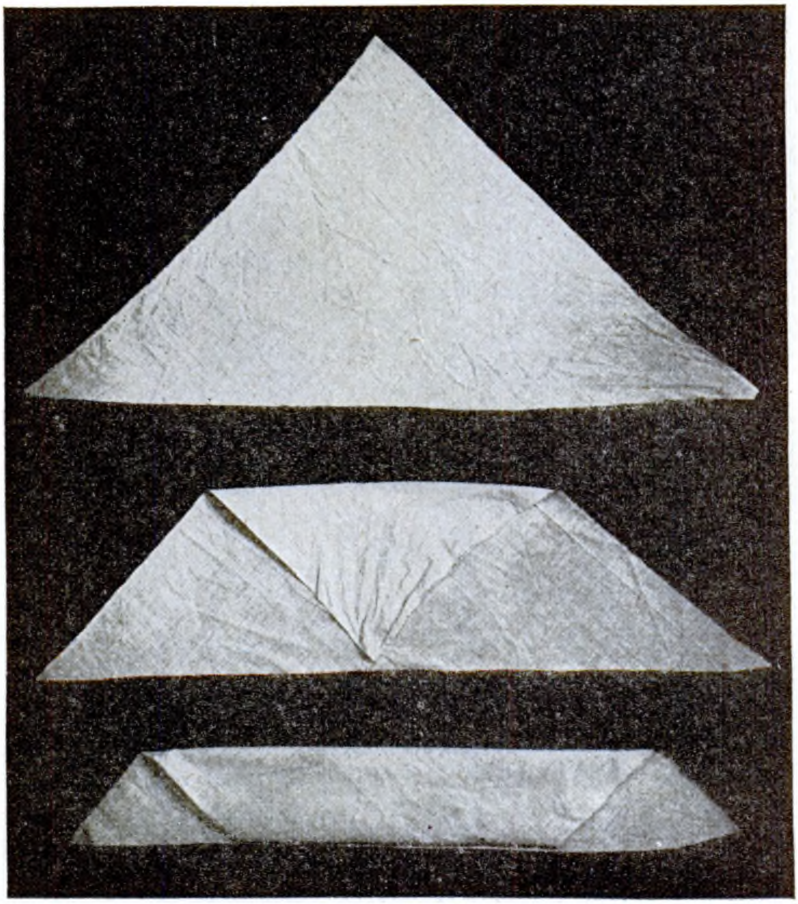

FIGURE 82.—Folding cravat from triangle.

Fronto-occipital triangle.—Place the middle of the base of the triangle on the forehead so that the edge is just above the eyebrows and bring the apex backward over the head, allowing it to drop over the occiput. Bring the ends of the triangle around to the back of the head, above the ears, cross them over the apex at the occiput, and carry them around to the forehead and there tie them in a square knot. Finally, turn up the apex toward the top of the head and pin with a safety pin, or turn up the apex and tuck it in behind the crossed part of the bandage. Uses: To retain dressings on the forehead or scalp (fig. 83).

Triangle of chest or back.—Drop the apex of the triangle over the shoulder on the injured side and bring the bandage down over the chest (or back) to the level desired and so that the middle of the base is directly below the shoulder. Carry the ends around the body and tie in a square knot on the back. Finally, bring the apex down on the back (or chest) and tie it in a square knot to one of the ends. Uses: To retain dressings on burns or wounds of the chest or back (fig. 84).

Brachio-cervical triangle, or arm sling.—The arm to be put in the sling should first be bent at the elbow so that the little finger is about a hand's breadth above the level of the elbow. Drop one end of the triangle over the shoulder on the uninjured side and let the bandage hang down over the chest with the base

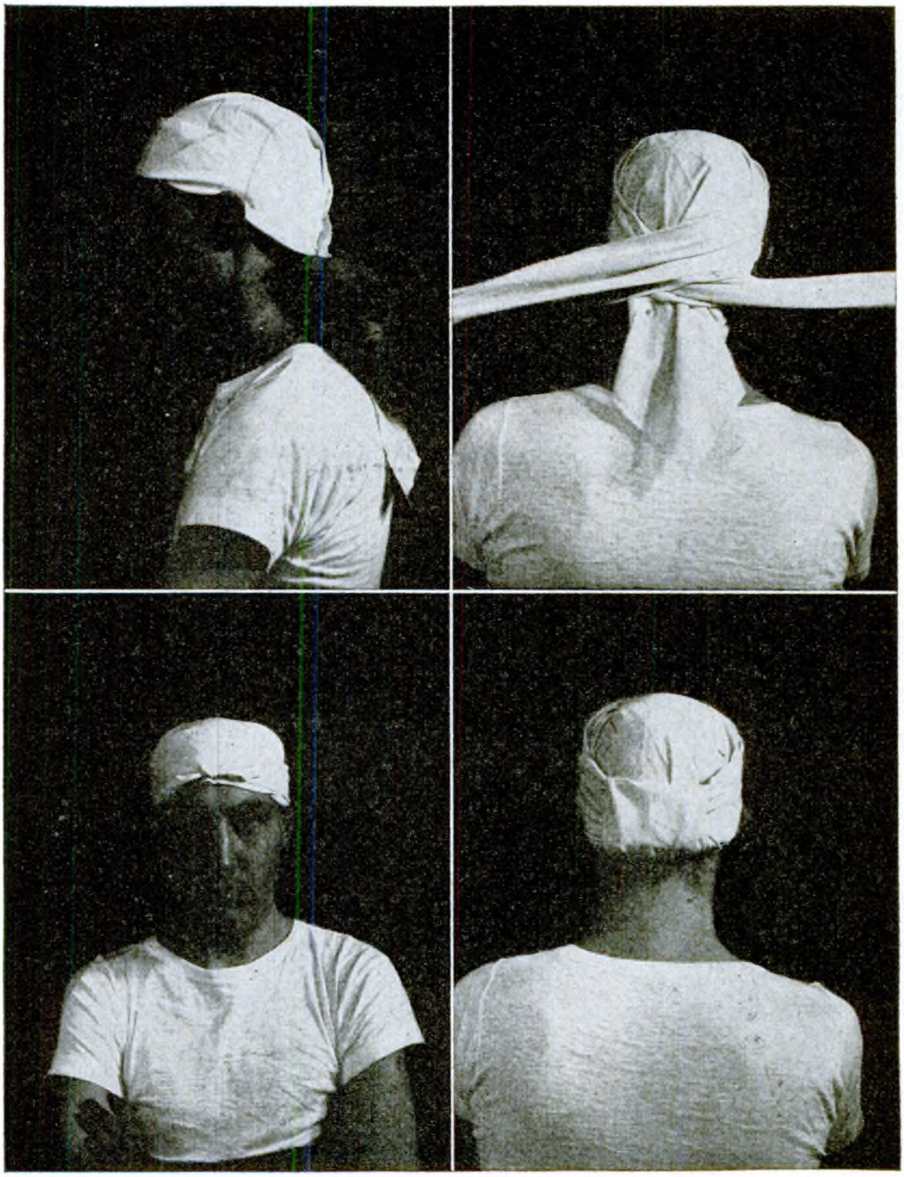

FIGURE 83.—Fronto-occipital triangle. (First-aid Textbook, A. R. C., modified.)

toward the hand and the apex toward the elbow. Slip the bandage between the body and the arm, carry the lower end up over the shoulder on the injured side and tie the two ends together at either side of the neck, using a square knot. Draw the apex of the bandage toward the elbow until it is snug, bring it around the elbow to the front, and after folding back a little fasten it to the front of the bandage with a safety pin. The lower end of the bandage may be passed between the arm and the body and under instead of over the injured

shoulder before tying to the other end. The ends of the fingers should extend slightly beyond the base of the triangle (fig. 85).

Triangle of hand.—Place the middle of the base of the triangle well up on the palmar surface of the wrist, carry the apex around the ends of the fingers

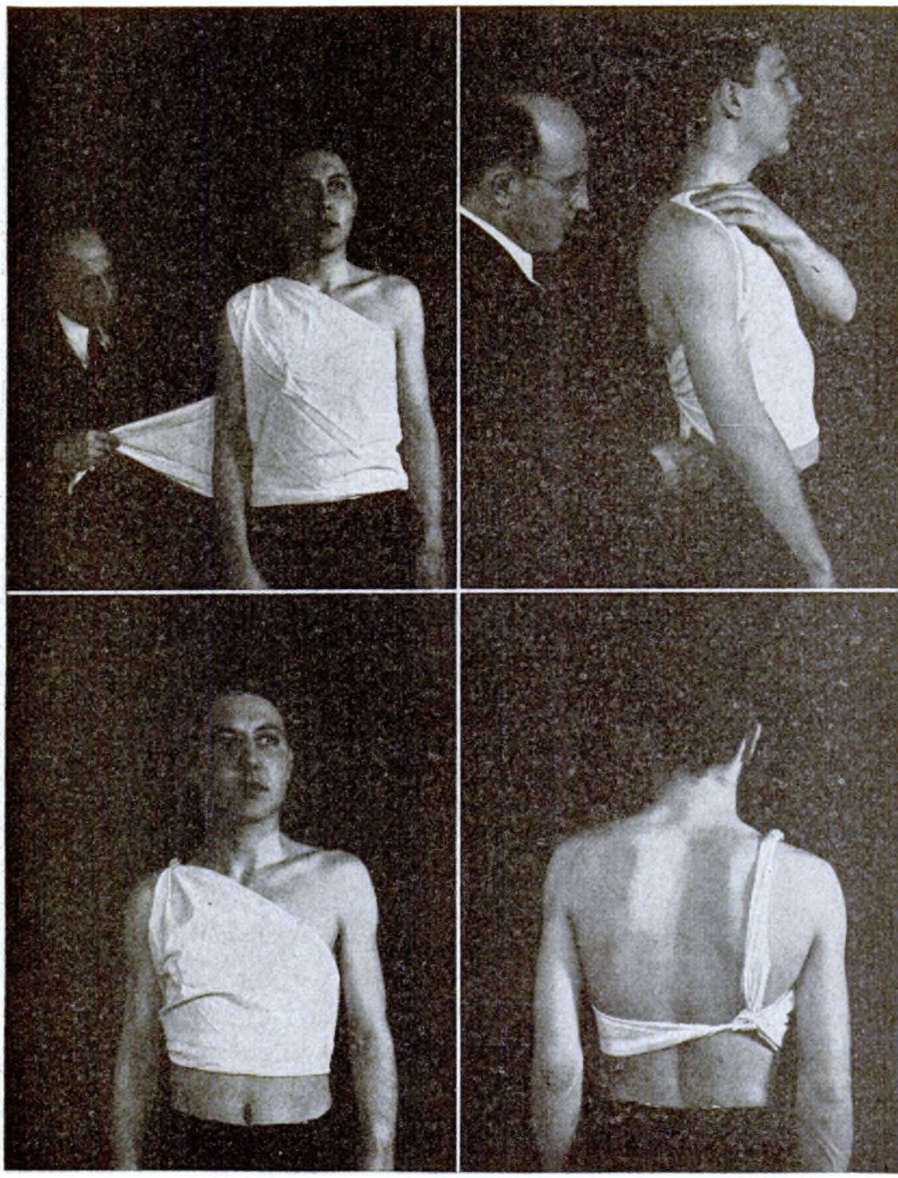

FIGURE 84.—Triangle of chest or back. (First-aid Textbook, A. R. C., modified.)

and over the dorsum of the hand to the wrist or forearm, fold each half of the part at the sides of the hand back toward the opposite side of the wrist, cross the ends around the wrist and tie in a square knot. Uses: To retain dressings of considerable size on the hand (fig. 86).

Triangle of foot.—Place the middle of the base of the triangle on the ankle well above the heel, carry the apex around the ends of the toes and over the

dorsum of the foot to the ankle, fold each half of the part at the sides of the foot back toward the opposite side of the ankle, cross the ends around the ankle and tie in a square knot. Uses: To retain dressings of considerable size on the foot (fig. 87).

Gluteo-femoral triangle.—To apply this bandage requires two bandages, one a triangle, the other a cravat. First fasten the cravat around the waist. Place

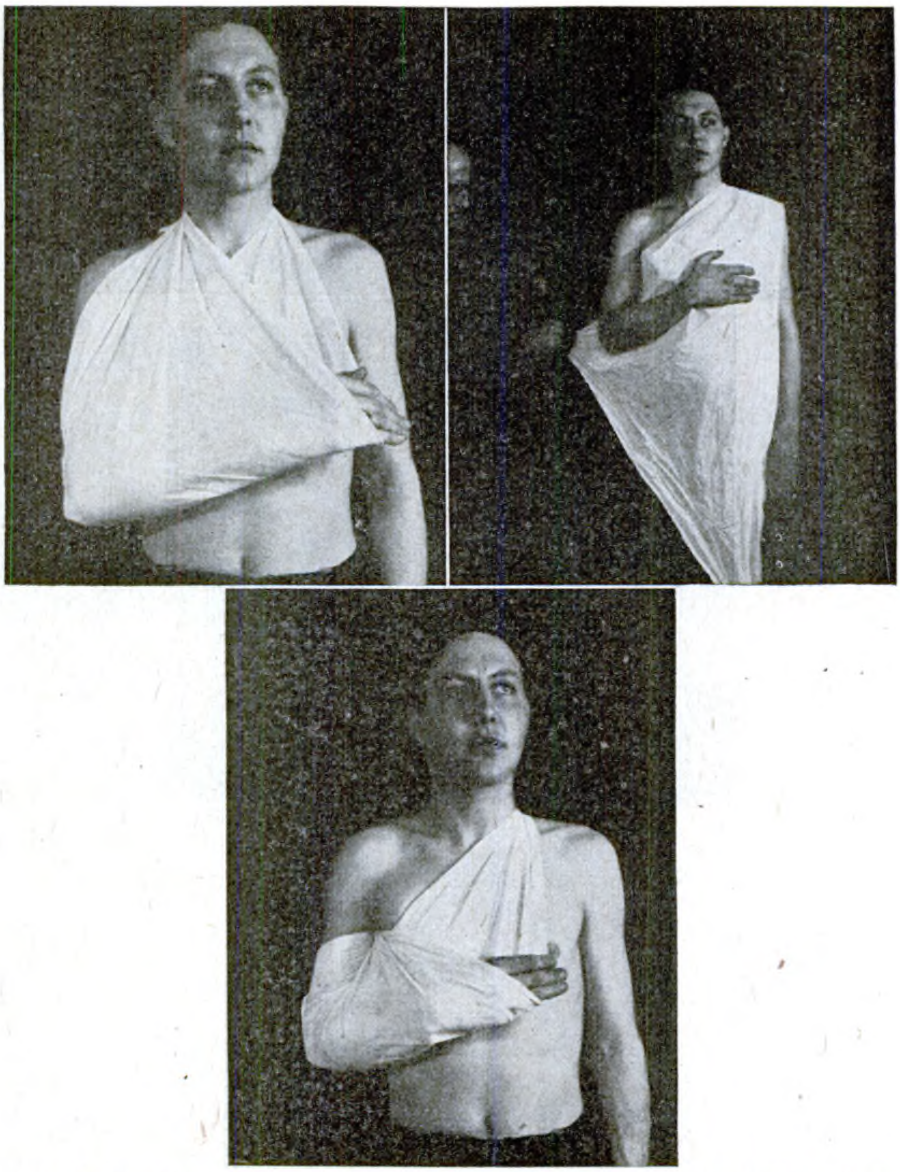

FIGURE 85:—Brachio-cervical triangle or arm sling and showing lower end passing between arm and body. (First-aid Textbook, A. R. C., modified.)

the base of the triangle in the gluteo-femoral fold, and carry the ends around the thigh to the front where they are tied with a square knot. The apex is then carried upward and passed under the cravat around the waist, turned

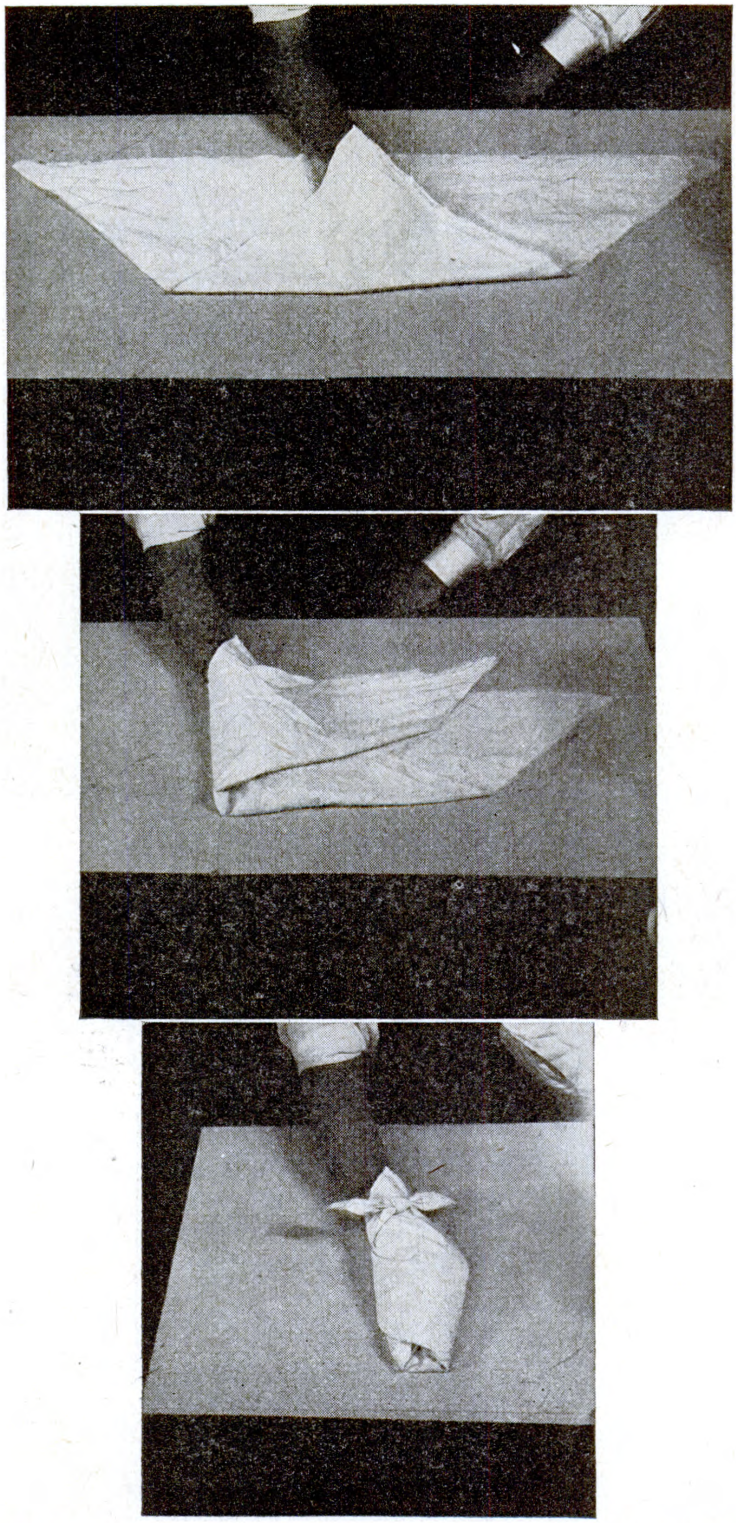

FIGURE 86.—Triangle of hand. (First-aid Textbook, A. R. C., modified.)

down and fastened to the triangle with a safety pin. Uses: To retain dressings on the buttock or hip (fig. 88).

Mento-vertico-occipital cravat.—After making a triangle into a cravat of the proper width, place the middle of the cravat under the chin, carry the ends

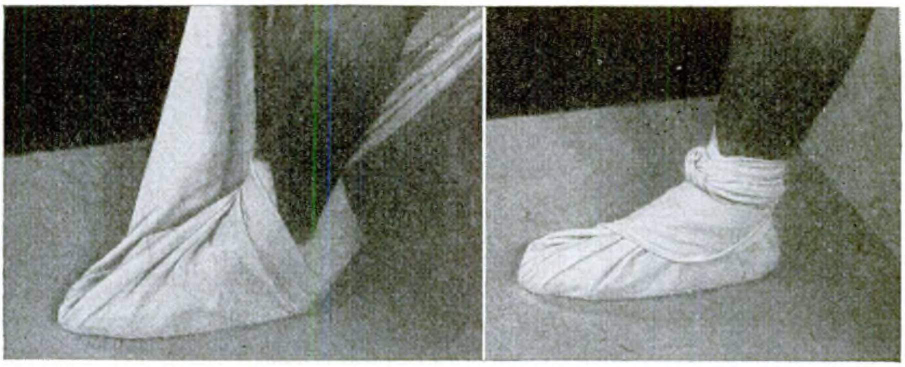

FIGURE 87.—Triangle of foot. (First-aid Textbook, A. R. C., modified.)

upward in front of each ear to the vertex of the skull crossing them there and continuing downward to the occiput where they are tied in a square knot. Uses: To retain dressings on the chin, cheeks, and scalp, and as a temporary dressing to secure fixation of the parts in fracture or dislocation of the jaw (fig. 89).

FIGURE 88.—Gluteo-femoral triangle. (U. S. Naval Medical School.)

FIGURE 89.—Mento-vertico-occipital cravat. (U. S. Naval Medical School.)

Bis-axillary cravat.—After making a triangle into a cravat of the proper width, place the middle of the cravat in the axilla, carry the ends upward to the top of the shoulder crossing them there and continuing across the back and chest respectively to the opposite axilla where they are tied in a square knot. Uses: To retain dressings in the axilla or on the shoulder (fig. 90).

Cravat of head or ear.—After making a triangle into a cravat of the proper width, place the middle of the cravat over the point desired, carry the ends to the opposite side of the head, cross them, and bring them back to the starting point and tie with a square knot. Use: To apply pressure to control serious hæmorrhage from wounds (fig. 91).

FIGURE 90.—Bis-axillary cravat. (U. S. Naval Medical School.)

FIGURE 91.—Cravat of head or ear. (U. S. Naval Medical School.)

REFERENCES

Minor and Operative Surgery, Including Bandaging.—Wharton.
Bandages and Bandaging for Nurses.—Cowan.
American Red Cross First Aid Textbook.

Section 3.—SPLINTS AND APPLIANCES

The illustrations and most of the text in this section are taken from the Manual of Splints and Appliances of the U. S. Army, and the courtesy of the War Department, Office of the Surgeon General, in permitting the use of that manual is herewith acknowledged.

In the foreword to the third edition of the Manual of Splints and Appliances of the U. S. Army it is stated that the number of splints and appliances is confined to as few as possible for adequate treatment and the designs meet the qualifications of efficiency and correct mechanical principles; simplicity of design and low cost of construction; and transportability, so that an efficient splint may be applied and remain in place until the patient reaches the hospital for definitive care. Many of the splints and appliances in the Manual have the outstanding advantages of quick manufacture and ease of distribution, the combination of traction and fixation in the same apparatus, and constancy of type and simplicity of mechanical principle, making it readily understood and easily applied.

Splints should be applied so as to assure fixation and traction, thereby reducing the chances of infection and minimizing the pain and shock during transportation.

THE SPLINTING OF FRACTURES FOR TRANSPORTATION

The necessity of splinting of fractures before transportation is attempted cannot be over-estimated. It lessens pain, shock, and additional damage to bone and soft parts.

Compound fractures are not further contaminated, shortening is prevented, and reduction is made less difficult.

The primary mortality rate of 50 per cent in compound fractures of the femur in the British Army during the World War was reduced to 15 per cent by proper splinting alone.

Every major fracture in the long bones should be splinted "where they lie" before transportation is attempted.

The proper splinting of peace-time fractures is equally as essential as the care of war-time injuries.

Army hinged half-ring thigh and leg splint.—(Keller leg splint).

The side arms of the splint are made of ⅜-inch cold rolled steel or Bessemer steel rod. The half-ring of same material ½ inch in diameter.

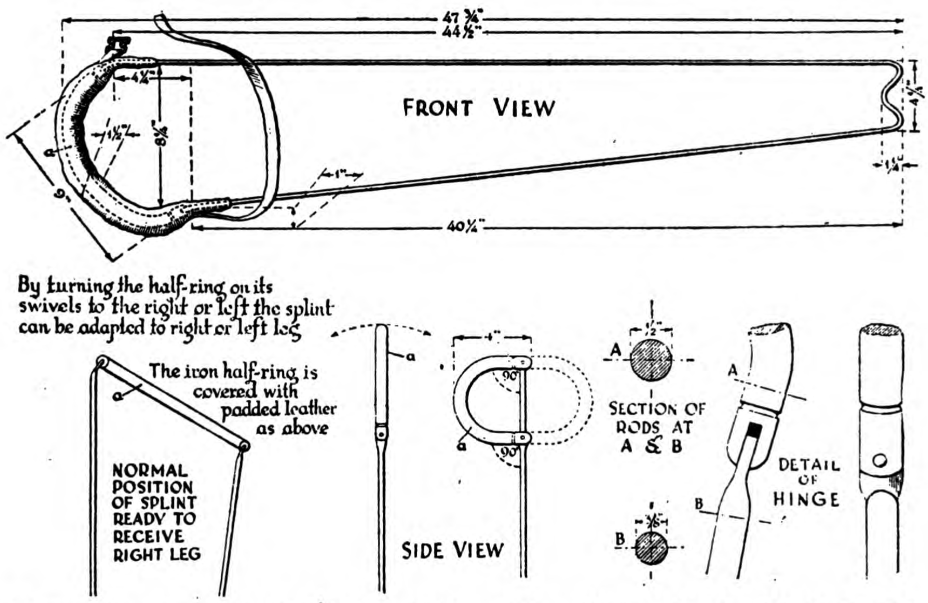

FIGURE 92.—Army hinged half-ring thigh and leg splint (Keller). (U. S. Army.)

The half-ring is covered with an inner layer of ½-inch felt and an outer layer of ¼-inch felt. The felt is covered with first-cut horse hide, cream color, not oiled or dressed, and free from material that might irritate the skin. The leather is neatly and securely sewed with waxed linen thread, using a baseball stitch (about four to the inch). The covering is so stitched that the surface coming into contact with the patient is smooth. The finished padded portion is about 1¼ inches in diameter. The inner layer of felt stops at the joint, being tapered for a distance of about 1¼ inches just above the joint to allow for the thickness of the webbing strap over which it is sewed. The outer layer of felt stops 1¼ inches below the joint, the ends being tapered for a distance of approximately 2 inches and cut transversely to permit passage of the webbing strap. The stitching is continuous and is carried through the webbing (fig. 92).

USES.—

Transportation and fixed traction of—

1. Fractures of the femur.
2. Fractures and injuries of the knee.
3. Fractures of the tibia above the ankle.

Definitive care.—Suspension traction treatment of fractures of—

1. The femur.
2. The tibia and fibula.
3. Other injuries and orthopedic conditions of the lower extremity.

Splint strap, adjustable traction.

This is accessory to the Army hinged half-ring splint for transportation.

The adjustable traction splint strap is made of 1-inch nonelastic webbing. It consists of a main loop, a retention strap with buckle, and an extension strap with swivel. The loop is 14 inches in circumference and is designed to fit over the instep. A 12-inch strap without buckle and a 2½-inch strap

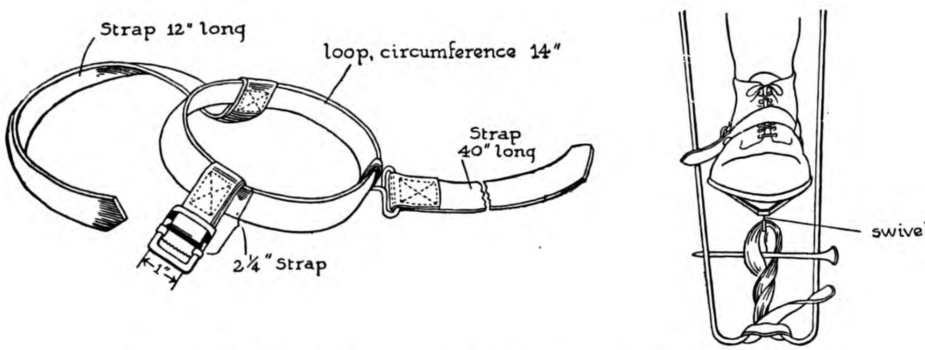

FIGURE 93.—Splint strap, adjustable traction. (U. S. Army.)

with a 1-inch chrome-plated nickel-steel release buckle are sewed to the loop in a manner which will retain the loop in proper position across the instep when the 12-inch strap is passed back of the ankle and buckled just posterior to the external malleolus. A 40-inch strap attached to the loop by means of a swivel is provided for the purpose of applying extension (fig. 93).

The adjustable traction strap is applied over the shoe of the patient and attached to the lower end of the Army hinged half-ring splint to secure fixed traction.

Traction is increased by the Spanish windlass principle.

The illustrated ankle hitch or the Collins' hitch, using a muslin bandage may be used as a substitute (fig. 94).

The shoe should never be removed in the field.

When clothing has been removed the extremity should be shaved and skin traction applied as shown in figure 108, the rope from the spreader being fixed to the end of the splint to obtain traction.

Splint support and foot rest.

This appliance (fig. 95) is made of ¼-inch cold rolled steel or Bessemer steel rod and its efficiency depends upon its spring—therefore the rod should be worked cold, as heat will remove the temper.

For use two are required. One is attached to the lateral bars of the Army hinged half-ring splint, with the arms of the appliance toward the distal end

of the splint after the leg has been fixed in the splint. It supports the distal end of the splint, allowing the leg to be suspended in the splint and not resting on the ground, litter, or table.

A second one is secured in a similar manner with the arms extending upward and to it the foot is secured by a triangular bandage.

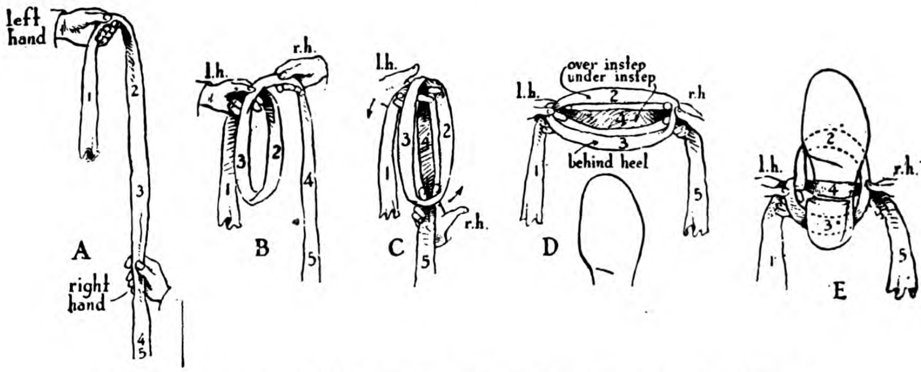

FIGURE 94.—Ankle hitch using muslin bandage. (U. S. Army.)

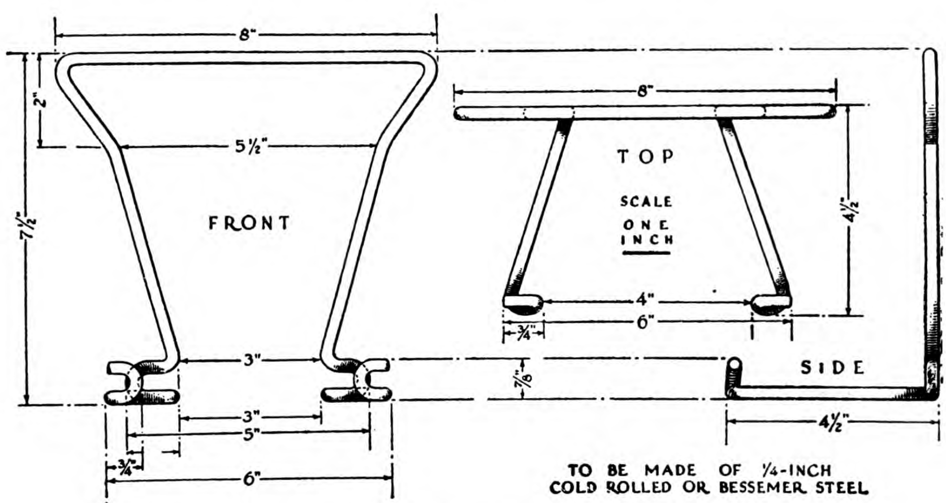

FIGURE 95.—Splint support and foot rest. (U. S. Army.)

Allow the splint support to rest on the canvas of the litter and secure it to the stirrups of the litter by means of straps or bandages.

See figures 96 and 97 for use of this appliance, supported by old-type stretcher bar.

Application of immobilization by traction-fixation of major fractures of the lower extremity for transportation.

For this purpose the following equipment is required: Army hinged half-ring splint; adjustable traction splint strap; two splint support and foot rests; and five triangular bandages. In the application of the traction-fixation splints for transportation, two men "A" and "B", work together and carry out the following procedures:

1. "A" grasps and makes traction on the foot of the patient while "B" applies the traction strap or ankle hitch over the shoe.

2. While traction is continued by "A", if the fracture be compound, "B" cuts away clothing about the wound, applies tincture of iodine and then an occlusive dressing (first-aid packet).

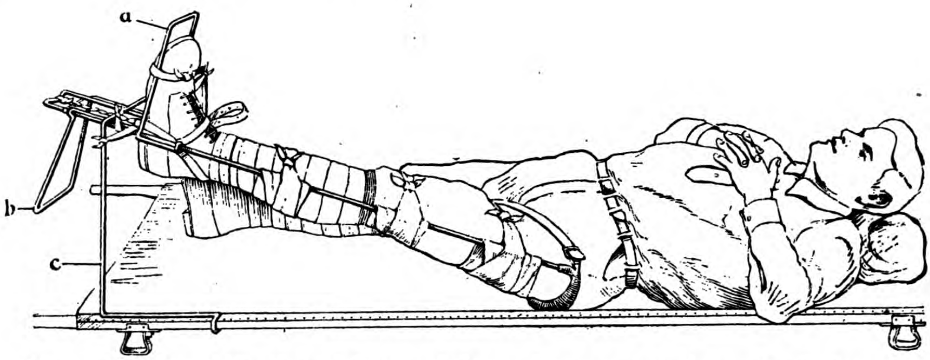

FIGURE 96.—Immobilization of fractured femur for transportation. (U. S. Army.)

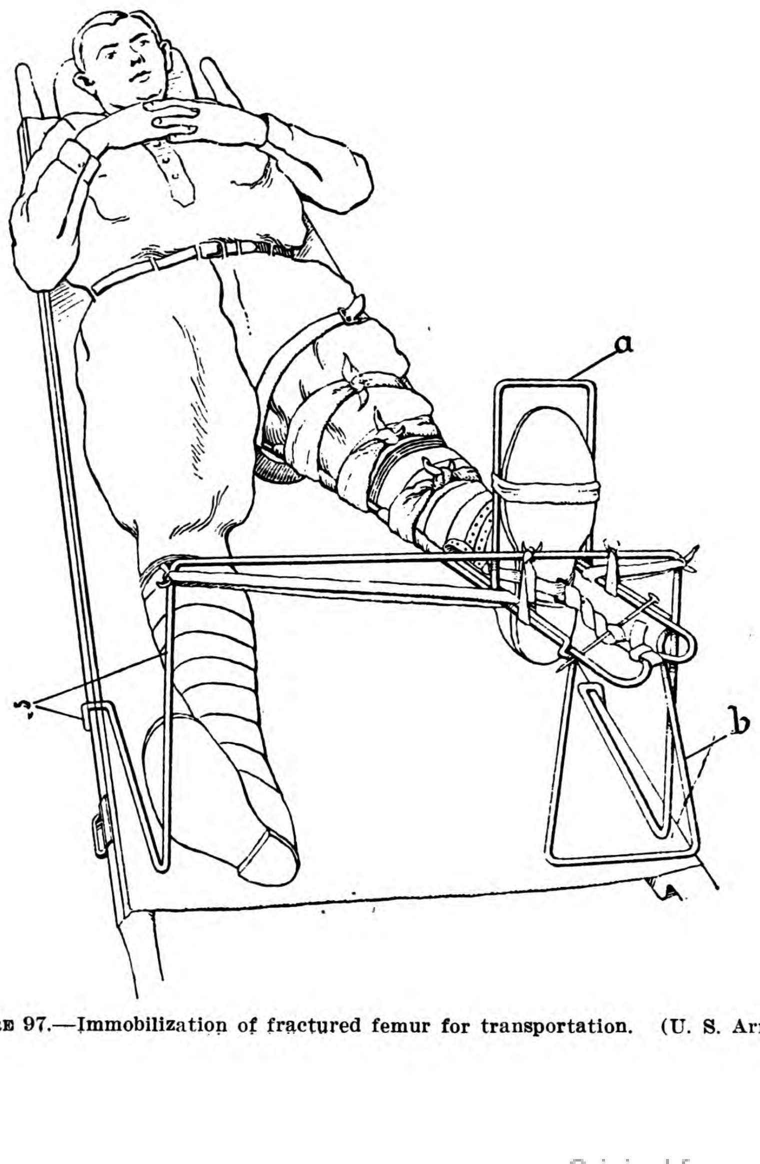

FIGURE 97.—Immobilization of fractured femur for transportation. (U. S. Army.)

3. While traction is continued by "A", "B" adjusts the Army hinged half-ring splint (right or left), locking the half-ring at a right angle to the bars of the splint, slides the splint in under the leg and secures the ring against the tuberosity of the ischium, tightening the anterior strap to hold it there.

4. "B" secures the traction strap to the end of the splint and increases traction by the Spanish windlass method. "A" lets go his traction on the foot.

5. "A" attaches the splint support to the splint which elevates splint from the ground and assists "B" in securing the extremity to the side bars of the splint, using four or more triangular muslin bandages.

6. "A" attaches the foot support to the splint and ties the foot in position against it, using a triangular bandage.

7. "A" and "B" place the patient on the litter and rest the splint support on the canvas of the litter, securing it to the stirrups of the litter by means of straps or bandages. (If a litter bar is attached to the litter the splint support is locked in the groove on the bar.)

Pierson attachment for Army hinged half-ring leg splint.

This attachment (fig. 98) is constructed of cold rolled steel or Bessemer steel rod and is U-shaped, 24 to 25 inches long, 6½ inches wide at the open end and 4¼ inches at the other. To each open end is attached a metal hinge,

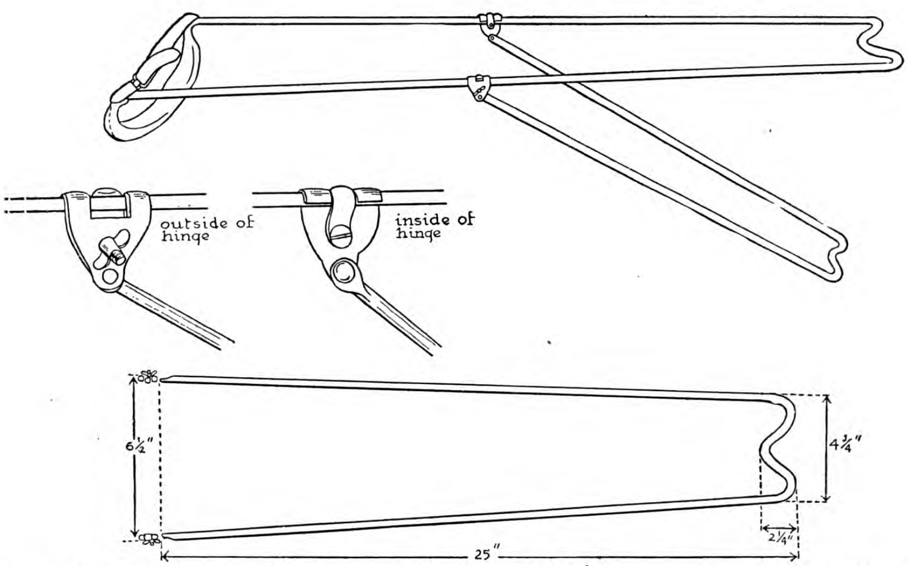

FIGURE 98.—Pierson attachment for Army hinged half-ring leg splint. (U. S. Army.)

freely moveable on the Pierson attachment and which will lock the attachment to a fixed place on the Army hinged half-ring splint. Its uses are in supracondylar fractures where knee flexion is necessary for the reduction of the fracture in conjunction with skeletal traction, and in suspension-traction treatment of all thigh and leg fractures to allow early knee motion, and in other conditions when traction and knee motion are desired.

Splint, Liston long interrupted.

This splint (fig. 99) is interchangeable, right and left, and consists essentially of a long member, a short member, a vertical foot piece, and a T-shaped cross member, constructed of ash or other suitable wood, and an offset metal U-shaped member. Dimensions and other details are illustrated in figure 100.

CONSTRUCTION.—The long and short members are jointed together by the offset metal U-shaped member which is fastened thereto by a T-shaped attachment upon each side arm. The attachment of this metal member is effected by means of four ¼-inch head bolts with square nuts. On the inner side of

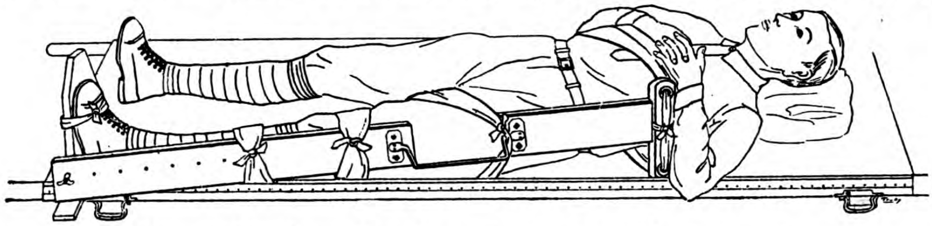

FIGURE 99.—Liston long, interrupted splint. (U. S. Army.)

the splint $\frac{1}{32}$-inch rectangular reinforcement plates, or suitable washers, are interposed between the wood and the bolt heads. It is important that the cross arm at the top of the splint be secured with four screws as well as glued.

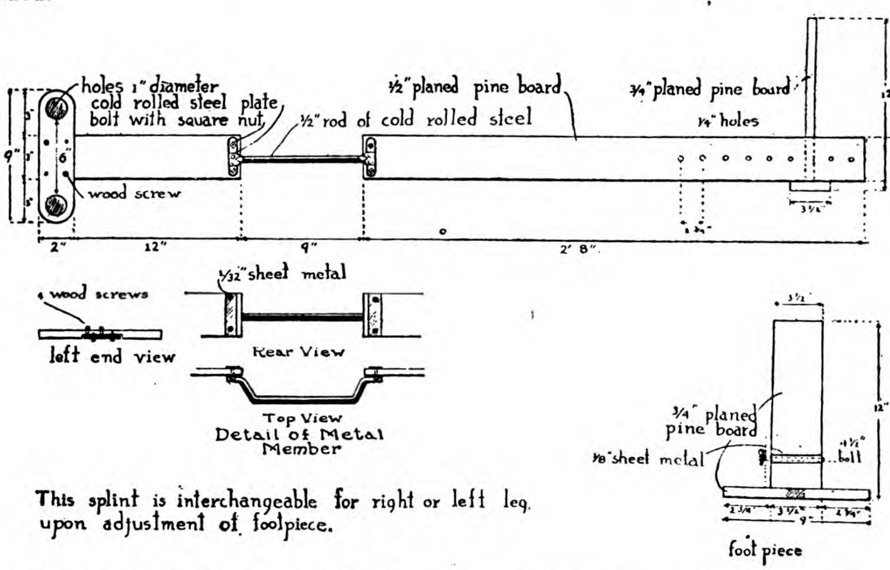

FIGURE 100.—Detailed drawing of Liston long, interrupted splint. (U. S. Army.)

USES.—

1. Fractures of the femur, knee or tibia with injury about the ischial tuberosity so that the half-ring splint cannot be applied.
2. Injury to the pelvis and hip where fixation is required.

This splint is reinforced by additional bandages or slings for the support of the leg or thigh when indicated. Additional splinting, using the wire ladder splint or pieces of the basswood splint board, is added as indicated.

Splint, wire ladder (fig. 101).

CONSTRUCTION.—The frame is made in the form of three sides of a rectangle, 3½ by 31 inches, one short side missing, made of No. 9 B&S gauge malleable iron wire.

2. The cross pieces are made of one continuous piece of No. 15 B&S gauge malleable iron wire shaped in the form of a gridiron with parallel bars about ⅝ inch apart.

3. The gridiron section of wire is attached to the frame by tightly wrapping with a malleable iron wire of about 22 B&S gauge. Three turns to each lateral section and two in between. Ends are well wrapped and secured.
4. Following assembly the splint is heavily galvanized.

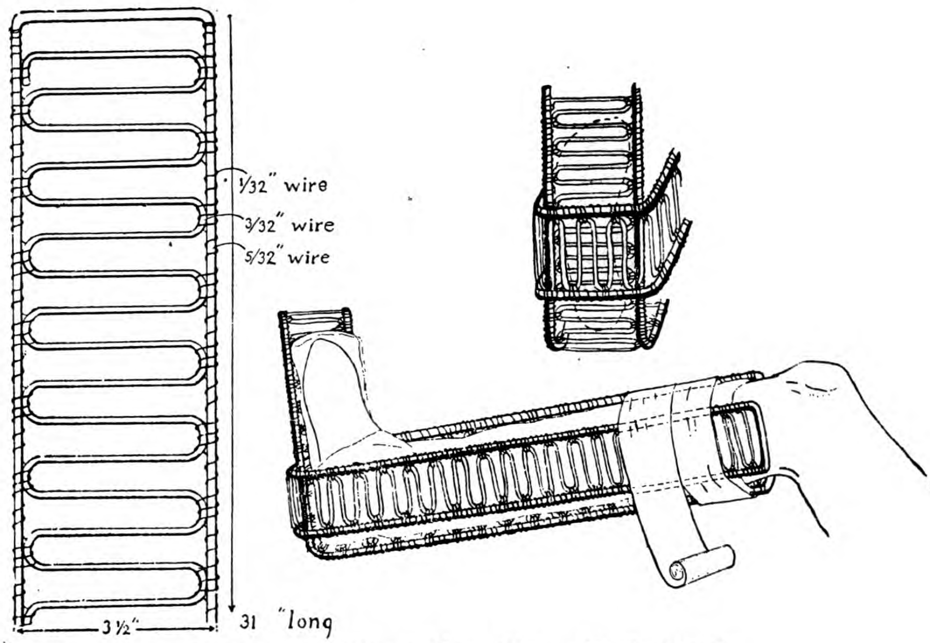

FIGURE 101.—Wire ladder splint. (U. S. Army.)

USES.—
1. Splinting for transportation of Pott's fractures, injuries and fractures about the ankle and foot. (Gauze–cotton pads in peace time and first-aid packet, large, in war are used as padding. The splints, when padded and applied, are held in position by a bias muslin bandage.)
2. As coaptation splints in the field or in hospital.
3. Where a malleable light splint is required for a temporary period, as for the shoulder, elbow, or wrist, to maintain a fixed position other than that of extension.

Splint, Thomas, arm, hinged, traction.

This splint (fig. 102) is made of ¼-inch cold rolled or Bessemer steel rod, gray saddle felt, and NS—3 horse hide.

The ring is protected with gray saddle felt covered with first-cut horse hide, cream color, not oiled or dressed and free from material that might irritate the skin. The leather is neatly and securely sewed with waxed linen thread, using a baseball stitch (about four to the inch). The covering is so stitched that the surface coming into contact with the patient shall be smooth. The finished padded portion is about 1¼ inches in diameter.

USES.—
1. Injuries to the shoulder joint.
2. Injuries to the shaft of the humerus.
3. Injuries to the elbow joint.
4. Injuries to the upper one-third of the forearm.

A hitch about the wrist to obtain traction is forbidden.

A method of application to the upper extremity, using two persons, "A" and "B" follows:

1. "A" grasps the hand and makes traction. "B" determines site of fracture, removes all clothing to shoulder and if the fracture is compound, iodizes the wound and applies an occlusive dressing.

2. "B" applies adhesive traction to the dorsal and volar surfaces of the arm from the fracture point or above down to the wrist. The adhesive is doubled back on itself over the hand, so that it will not adhere—2½- or 3-inch

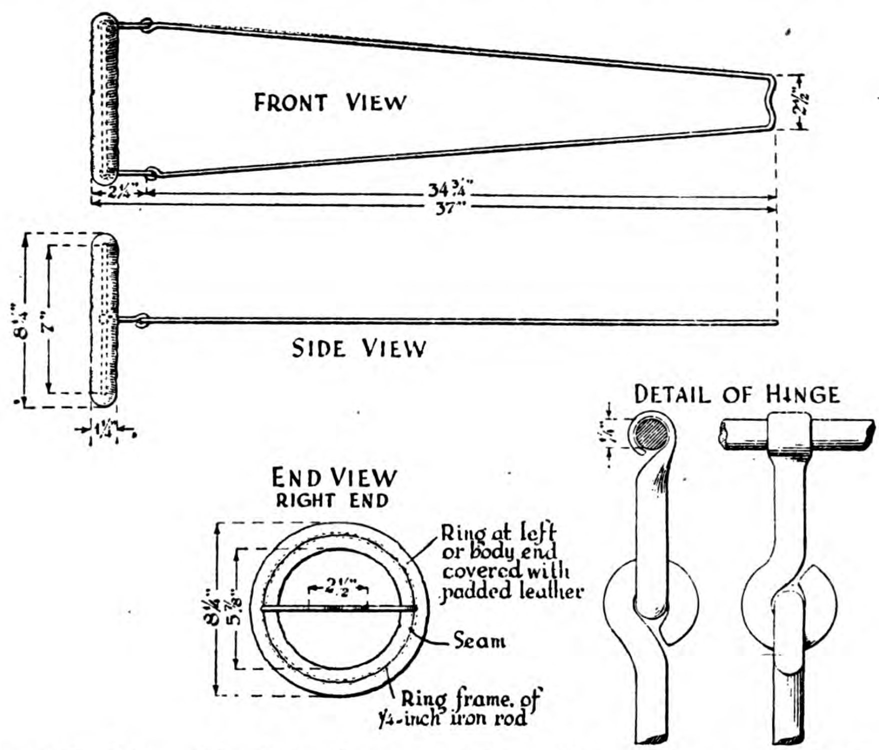

FIGURE 102.—Thomas hinged, traction arm splint for right or left arm. (U. S. Army.)

adhesive is used and is covered with a gauze bandage to promote adherence. A short piece of light $\frac{3}{16}$- or ⅛-inch braided cotton rope is tied to the end of each of the two adhesive straps.

3. While "A" still makes traction, "B" threads the arm through the ring of the hinged ring traction splint until it rests against the chest wall and shoulder girdle. He then ties the ropes from the adhesive traction straps to the end of the splint. A small sliver of wood is passed between the adhesive straps at the finger tips to prevent tortion of the adhesive on the hand, while "B" increases traction with a second wooden sliver between the ropes by the Spanish windlass method.

4. "A" and "B" secure the arm and forearm to the side bars of the splint, using three or more triangular bandages.

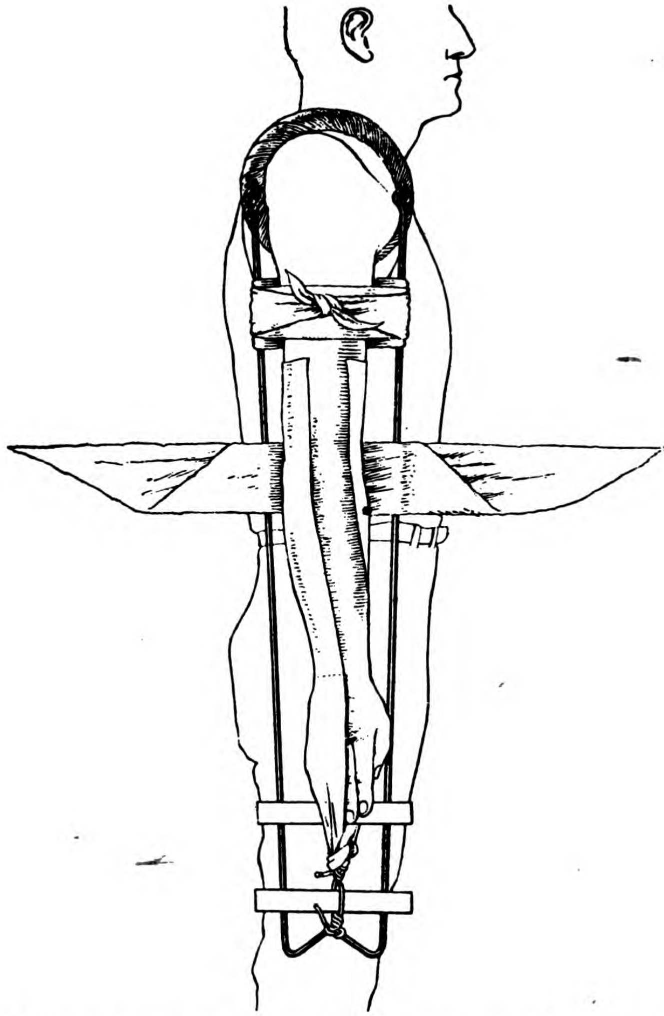

FIGURE 103.—Thomas hinged, traction arm splint applied. (U. S. Army.)

SPLINTS AND APPLIANCES FOR DEFINITIVE CARE OF BONE AND JOINT INJURIES

Balkan Frame.

The following material is required for erection and use of a Balkan Frame:

Bag, buckshot, 3-inch, holds 1 pound		10
Bag, buckshot, 5-inch, holds 5 pounds		10
Bag, buckshot, 8-inch, holds necessary number of 1- and 5-pound shot bags		5
Buckshot, coarse	pounds	50
Clamp, large (Detail C)		10
Clamp, small (Detail D)		10
Hammock for suspension of pelvis, large		1
Hammock, small		1
Poles (Detail A)	set	1
4 feet by 1¾ by 1 inch 3		
6 feet by 1¾ by 1 inch 5		
8 feet by 1¾ by 1 inch 4		
Pulley assemblage (Detail B)		8
Rope, $\frac{3}{16}$-inch, braided cotton, unglazed	yards	30

Details of metal parts and timber are shown in figure 104.

USES.—The Balkan Frame is used for suspension of: Upper extremity; lower extremity; fractures of the pelvis; and the whole body when in plaster.

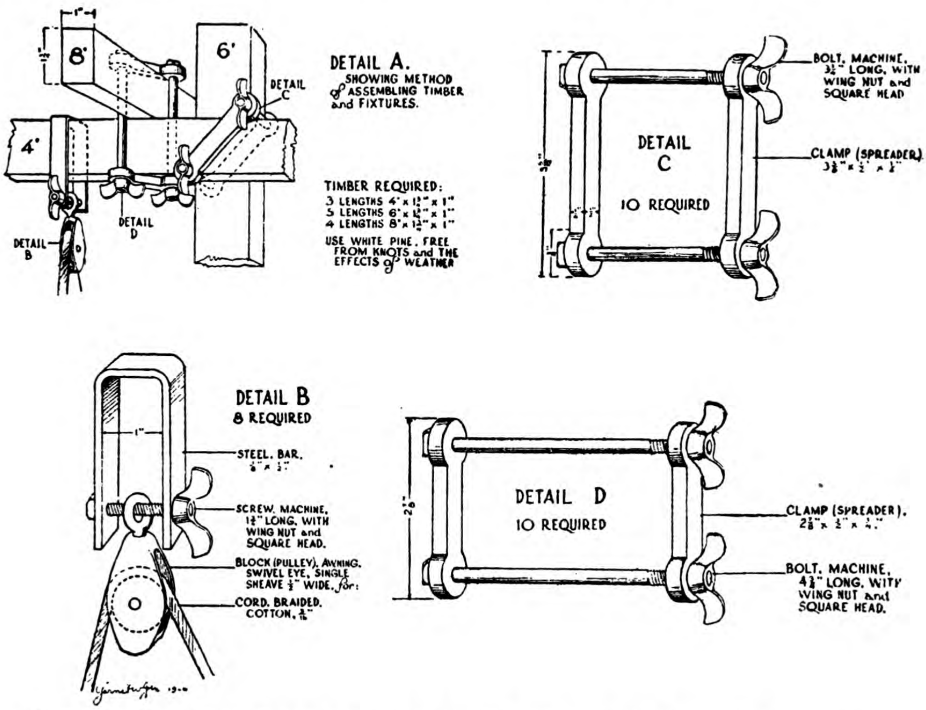

FIGURE 104.—Balkan Frame; details of metal parts and timber. (U. S. Army.)

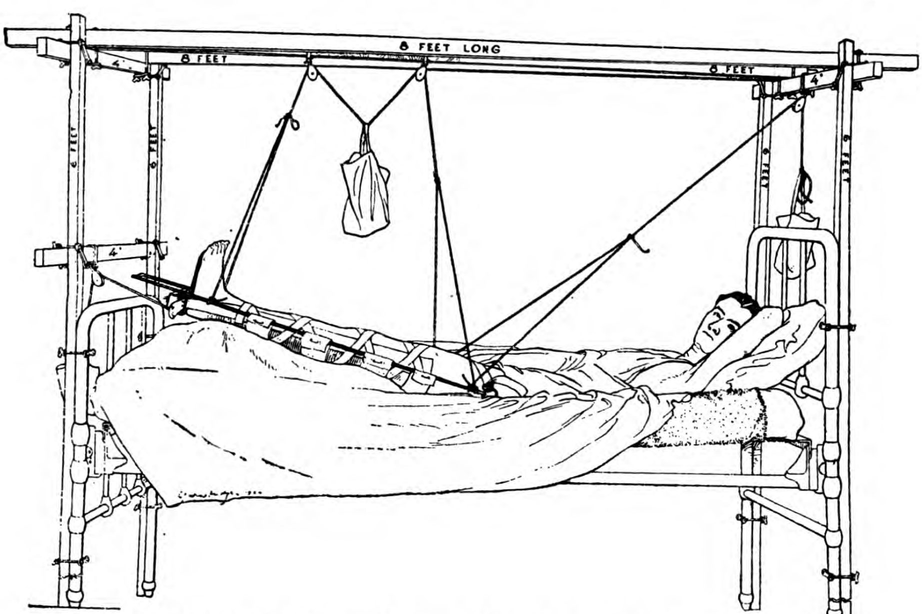

FIGURE 105.—Balkan Frame; side view. (U. S. Army.)

When assembled (fig. 105), the middle over-head pole of the frame from which the leg is suspended is placed parallel with the long axis of the leg. Sufficient weight (1- and 5-pound shot bags) is placed in the open-mouthed bag to balance the weight of the splint and leg. The rope going over the pulley at the head of the bed carries sufficient weight (about 8 pounds) to hold the ring of the splint in position against the ischial tuberosity.

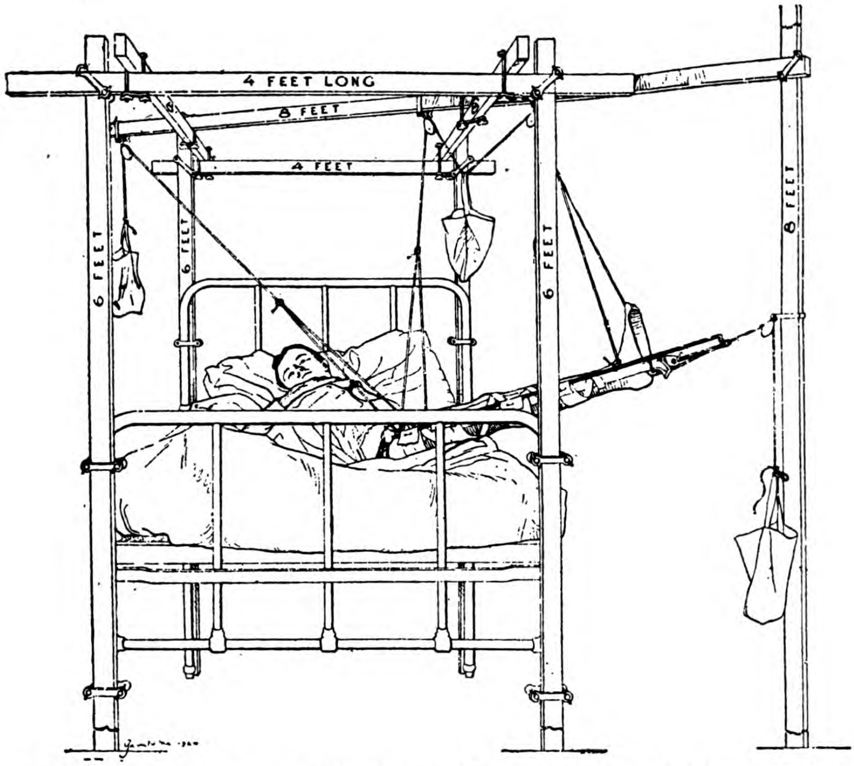

FIGURE 106.—Balkan Frame in use for fractured femur; thigh in abduction. (U. S. Army.)

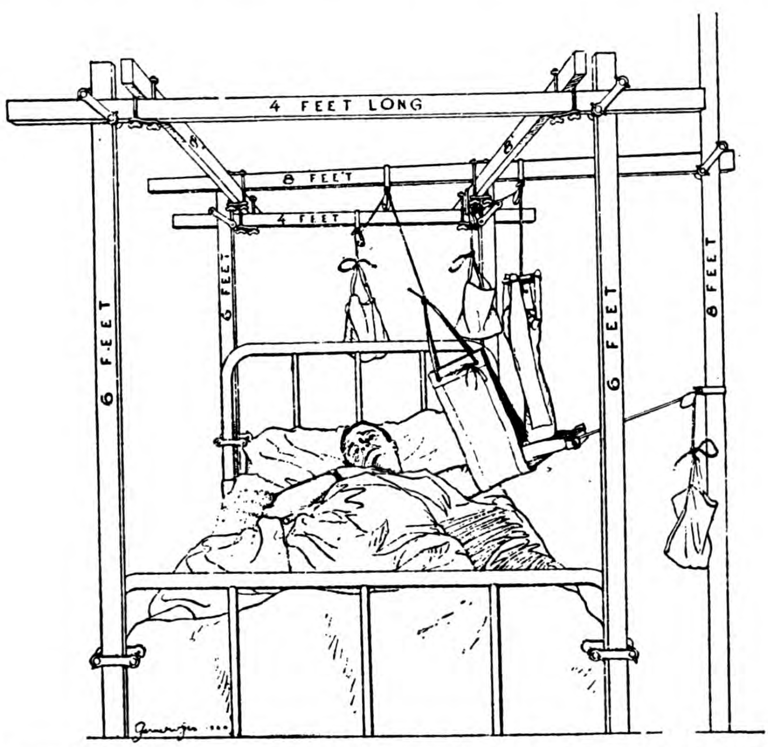

FIGURE 107.—Balkan Frame in use for fractured humerus. (U. S. Army.)

Traction is obtained by the use of adhesive plaster through the rope over the pulley at the end of the frame (25 to 30 pounds).

The extremity is suspended in the splint by the use of 5-inch canton-flannel bandages as slings, using large safety pins for fixation.

Length is obtained by weight and pulley traction, alignment by abduction, adduction, flexion, or extension of the distal end of the splint (distal fragment). Alignment is also changed by adjusting the position and tightness of the supporting canton-flannel slings.

Figure 106 shows the Balkan Frame in use for an intertrochanteric fracture of the femur treated in extreme abduction, using skin traction.

The frame allows any position of abduction or adduction. All four extremities may be suspended at one time or any combination, including a fractured pelvis.

The foot of the bed is ordinarily elevated so that the body will better act as a counter weight against traction.

If there is a wound in the region of the ischial tuberosity the half-ring of the splint may be reversed to the anterior surface of the thigh and dressings held in place behind by the strap and buckle.

A "monkey bar" made of a broom handle and suspended from the frame by rope so that it hangs within reach of the patient is a welcome aid to him in changing his position in bed.

Figure 107 shows the Balkan Frame in use for a fracture of the humerus treated by skin traction in abduction.

The humerus is suspended in a canvas hammock 8 by 30 inches, with four eyelets above and a piece of board through both of which laces are passed.

The forearm and hand are suspended from a wooden spreader, made locally, using four 1-inch steel buckles and sufficient 1-inch nonelastic webbing.

A piece of broom stick makes an excellent hand hold.

Position of the distal fragment is changed by abducting or adducting the arm and likewise by changing the supporting pole of the suspending frame and by increasing or decreasing the weight attached to the forearm or that attached to the hammock.

Skin traction.

Application.—The skin is prepared by shaving, cleansing with gasoline and alcohol, and drying.

A strip of adhesive is rolled from a 3-inch spool and doubled on itself sufficiently so that this double thickness will extend from above the malleolus to the buckle of the spreader. The strip is then cut the length desired. A second strip is likewise prepared. A third strip is split in half to be used as the spiral. The lateral and mesial straps extend upward to the fracture site and are applied and bound by the spiral straps. It is applied evenly, wrinkling being avoided as it produces blisters (fig. 108).

The spiral should avoid the peroneal nerve over the neck of the fibula, the suprapatellar bursa, and not be bandaged tightly about the ankle. The leg is then bandaged with a gauze bandage to promote adhesion.

For below-knee traction, the adhesive extends only to the knee.

The spreader and foot support (fig. 108) are made locally from:

Sheet aluminum;
Webbing, 1½-inch, gray, nonelastic;
Buckle, 1¼-inch, two-prong;
Wood, 4¾ by 1¼ by ½ inch pine; and necessary
Tacks, rivets or screws.

The design of the spreader is from the Massachusetts General Hospital.

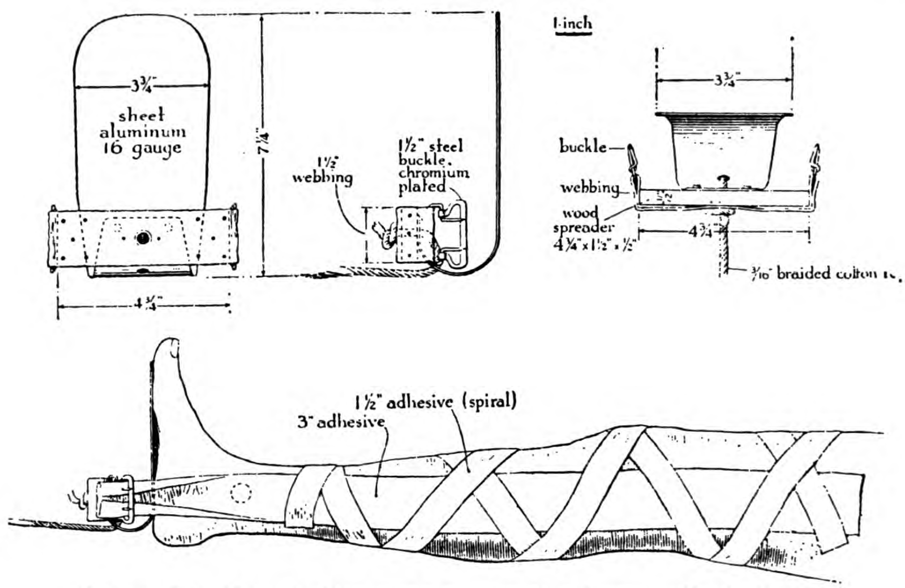

FIGURE 108.—Skin traction using zinc oxide adhesive. (U. S. Army.)

Splint, wire, Cabot posterior leg.

A figure approximating but not exactly that of a parallelogram, is constructed of ¼-inch cold rolled or Bessemer steel rod, with the free ends welded. One end, the welded, will measure 7¼ inches, the other end 4¼ inches. The small

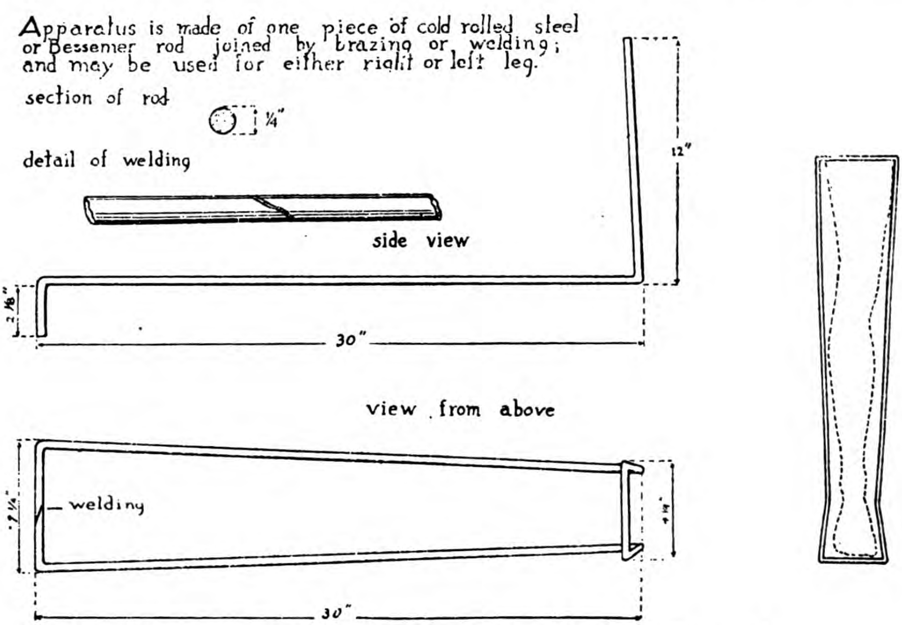

FIGURE 109.—Cabot posterior, wire leg splint. (U. S. Army.)

end of the frame is bent at a right angle to the plane of the frame 12 inches back from this end. The two sides measure 30 inches. The large end which has been brazed or welded, shall present concavity 2⅛ inches at its center.

This splint (fig. 109) is used for immobilization of the knee, ankle, foot, and soft parts of the leg.

Application.—A hammock is formed on which the extremity is supported in the steel frame by wrapping about it, not too tightly, a bias muslin bandage. Additional padding may be added, using gauze and cotton pads as desired. The extremity should at no place rest on the metal bars of the splint. The splint may be bent at the knee to give any amount of flexion desired.

The extremity is bound to the splint, using additional muslin bandages.

T-splint for fractured clavicle.

This splint (fig. 110) is made locally of the following material: Wood, maple or hickory, 3 by 18 inches, 2 pieces; buckles for 1½-inch webbing, 6; felt, saddle, gray; stockinette, 3-inch; webbing, 1½-inch; and necessary carpet tacks, rivets or screws.

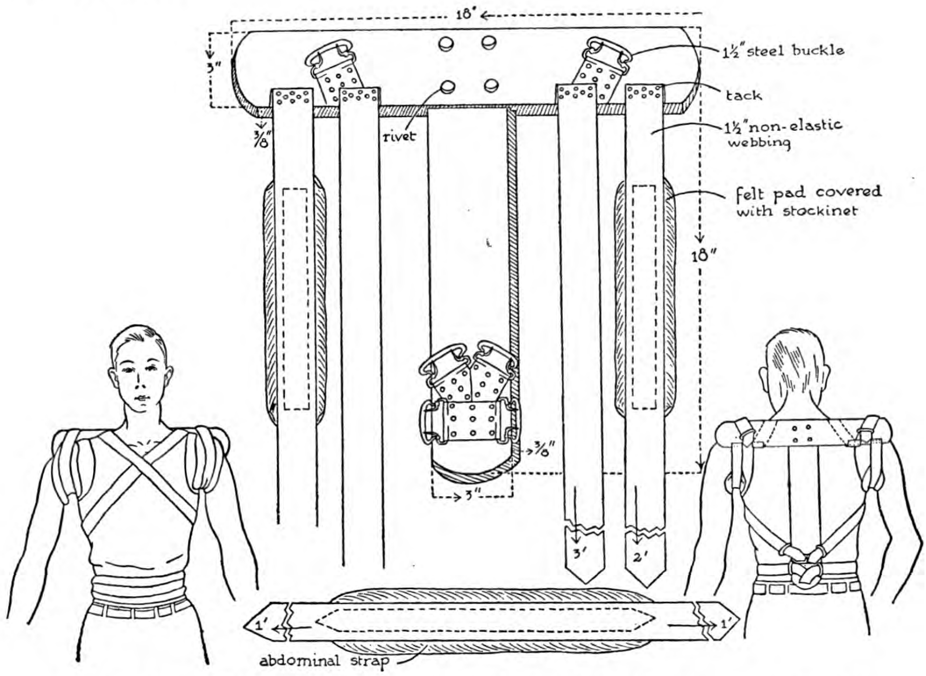

Figure 110.—T-splint with straps; for fractured clavicle. (U. S. Army.)

Construction.—The T is framed by mortising and fixing with rivets or screws the end of one piece of the wood with the middle of the other.

Straps and buckles are secured to the wooden T-splint by carpet tacks, as indicated.

Padding of saddle-felt covered with stockinette may be sewed to the straps which cause pressure under the axilla and to the abdominal strap, or, gauze cotton pads may be used, being pinned to the straps using safety pins.

These dimensions of the T are used for the average patient: Larger, 20-inch, and smaller, 16-inch; splints should be made up and available.

For infants and young children T-splints are made from basswood splint board, tacked together, padded, and fixed to the child with bandages and adhesive.

Application.—In fractures of the clavicle the shoulder drops downward, forward, and inward. The proximal fragment is usually pulled slightly anterior and upward. The splint is padded with saddle felt, or gauze cotton pads, held in place by adhesive.

Traction is made upward, outward, and backward on the shoulder to reduce the fracture. The splint is applied to maintain immobilization.

The inner strap on each side is brought up *under* the splint and over the shoulder at the base of the neck of the patient, crossed over the chest and secured to the two upper buckles on the lower end of the vertical arm of the splint. The abdominal strap is applied. Both shoulders are now pulled upward, backward, and outward by the axillary strap and fixed in this position. Straps are adjusted daily and skin under splint cared for.

Aeroplane or abduction splint.

This splint (fig. 111) is made locally of the following material: Buckles, 1½-inch, two-prong, 3; rod, ¼-inch steel, Bessemer or cold rolled, 12 foot lengths; sheet aluminum, 16-gauge; and webbing, 1½-inch gray, nonelastic.

Its measurements are—

1. Width of lower end of splint, average 7 inches, convex curve.
2. Distance from just below anterior superior spine of ilium to anterior axillary fold.
3. Length of arm, measured from anterior axillary fold to flexed elbow, arm in abduction.
4. Length of forearm, measured from flexed elbow to middle of palm of hand.
5. Line across palm, average 3 inches.

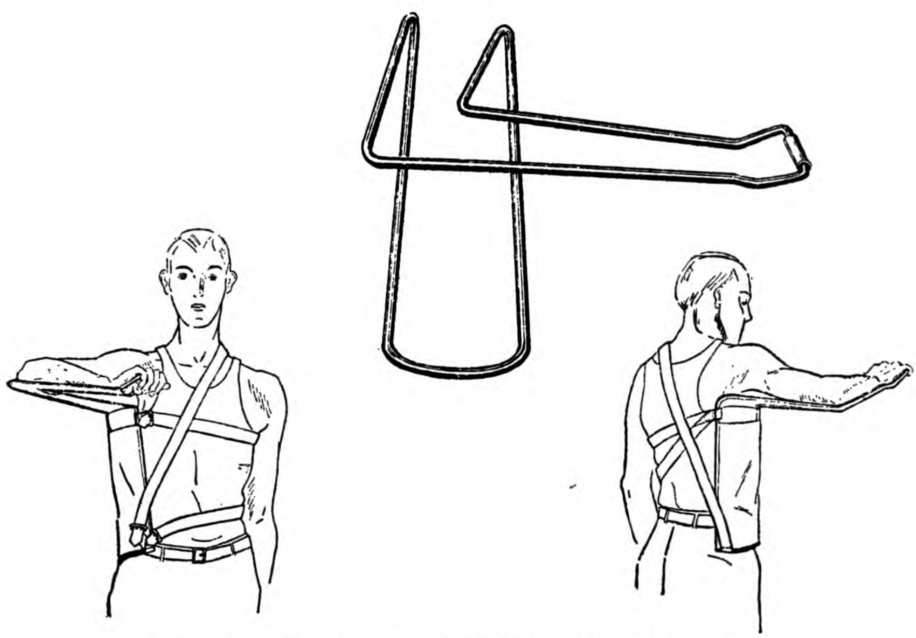

FIGURE 111.—Aeroplane or abduction splint. (U. S. Army.)

CONSTRUCTION.—The ¼-inch steel rod is bent cold (easily accomplished by use of vise and hammer). The rod is joined and fixed under hand piece by fixing ends of the rod in an aluminum cylinder. The aluminum cylinder is formed from a piece of aluminum ⅞ by 2½ inches, which is fashioned around a ½-inch steel rod using a vise and hammer.

Three nonelastic webbing straps and buckles are attached to the splint by sewing, as illustrated.

Canvas is sewed over the metal bars of the splint forming a hammock which supports the splint against the pelvis and chest wall and the arm and forearm on the splint. Gauze-cotton pads are added, as indicated. A bias muslin bandage may be used in lieu of canvas. The arm and forearm may be secured to the splint by a bias muslin bandage.

USES.—The aeroplane or abduction splint is used for—

1. Brachial-plexus injuries;
2. Paralysis or weakness of abductor muscles of shoulder;
3. Shoulder-joint injuries (other than dislocation);
4. Fractures of the scapula, of the surgical and anatomical necks of the humerus, and convalescent fractures of the shaft of the humerus;
5. Subacromial-bursitis; and
6. Acromio-clavicular dislocations.

Splint, basswood.

This splint material is used in the splinting of forearm and carpal fractures, and for coaptation splints.

When a splint is to be prepared for a Colles' fracture it should extend from just below the flexed elbow to the metatarsal-phalangeal joints, so as to allow free motion in these joints, and should be cut away over the thenar eminence so as not to produce "flat hand".

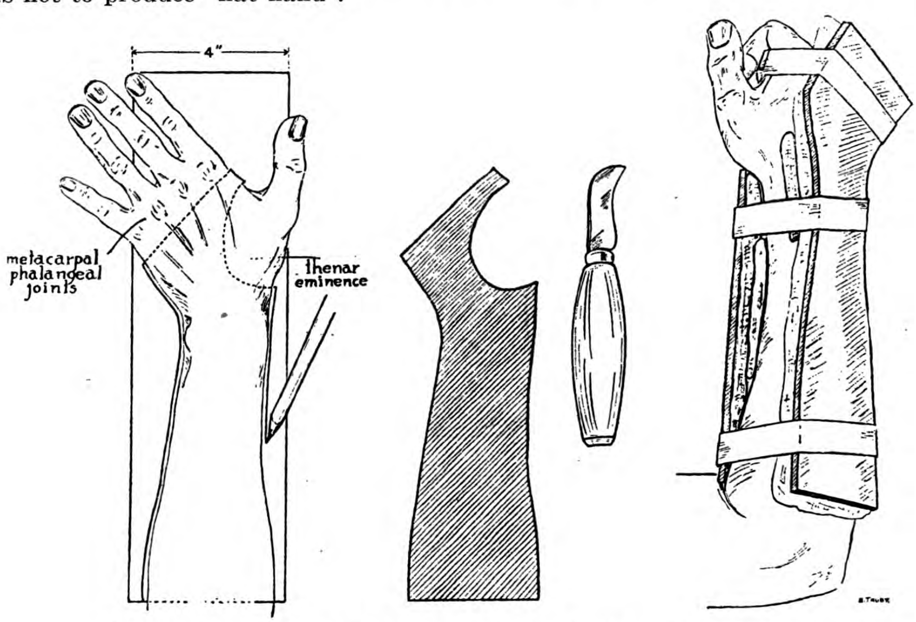

FIGURE 112.—Splinting of lower forearm fractures. (U. S. Army.)

The good forearm and hand, with hand in ulnar deviation, is placed palm down on a piece of splint board and outlined with pencil as shown in figure 112. The broken line is marked in after hand is removed from board. The posterior splint is marked out in a similar manner.

The splints are now cut out from the splint board, using a plaster knife, a pocket knife, or scroll saw, and sufficient layers of sheet wadding are laid on each splint and cut with a pair of bandage scissors to fit the splint. The padding is then secured to the splints with three or more narrow strips of adhesive.

In splinting a Colles' fracture after reduction, two additional pads are formed of sheet wadding. One, the longer of the two, is placed against the proximal

fragment and the palmar splint is placed in position. The second and smaller pad is placed over the distal fragment and the dorsal splint applied. While the splints are held in position an adhesive strap, 1 to 1¼ inches wide, is placed around the wrist, to be followed by a second one around the upper end of the splint, and a third around the lower end securing the hand in ulnar deviation. A gauze bandage is then applied.

Splints should show a "spring" when compressed by the operator's hand to insure that they do not bind too tightly.

For other forearm fractures splints are applied as in Colles' fractures, except that ulnar deviation may or may not be desired, and the position and size of the supplemental pads are changed as indicated to maintain reduction of fragments.

Section 4.—EMERGENCY DENTAL TREATMENT

Dental first-aid consists of skilled or semiskilled emergency treatment given to sufferers from disease and accidents involving the dental structures until regular dental care can be given. The treatment here suggested is intended only for the temporary relief of pain in the absence of a dental officer or when treatment facilities are inadequate. The effectiveness of dental first-aid depends upon an accurate diagnosis of the trouble to be treated and upon the correct application of the remedies indicated.

All cases receiving dental first-aid should be referred to a dental officer as soon as possible for further treatment. Pain, apart from accidents such as bruises and fractures, is a symptom or expression of some deeper pathological change within the tissues and is evidence of the need for further treatment. The purpose of dental first-aid treatment is to relieve pain, to prevent its recurrence, and to prevent the development of infection.

Hospital corpsmen on independent duty should do all in their power to remedy conditions which later may result in dental emergencies. Quite frequently naval personnel are on types of duty which preclude the possibility of obtaining skilled dental treatment within a reasonable length of time. It is for this reason that intelligent forethought should be exercised and the following suggestion considered very seriously in the interests of the comfort and welfare of the crew. Personnel of craft of any description for whom it is anticipated dental service will not be available should, prior to departure from a yard or base, have dental examinations and treatment. Until very recently (1936) this advice would have been impracticable on account of the limited number of dental officers in the Navy, but the allowance of these officers has been increased and it is now practicable to carry this suggestion into effect to a greater extent than ever before. Health records should be examined to see if they contain up-to-date dental records, and if lacking, these should be supplied. This is most important because it not infrequently happens that dental records furnish the only means of identification.

Whenever possible officers and men should be sent to a dental officer every 6 months for examination and treatment.

Advantage should be taken at isolated stations of the visits of naval or Coast Guard vessels carrying dentists. The services of Army, Public Health, Veterans' Administration, and Indian Service dental officers may be obtained in cases of emergency.

Dental treatment by dentists in civil life may be obtained in accordance with instructions contained in the Manual of the Medical Department. This manual authorizes emergency dental treatment for the relief of pain prior to authoriza-

tion by the Bureau of Medicine and Surgery, but ordinarily prior authorization must be obtained from the bureau. Read the manual, especially when in doubt.

Dental first-aid to be effective must be rendered by one who is acquainted with the structural and functional characteristics of the dental tissues. It is therefore absolutely necessary for the hospital corpsman to know the fundamental facts regarding the teeth and the related tissues.

Dental tissues.

The word dental is derived from the Latin word *dens*, meaning tooth. The dental tissues are those involved in the formation and structure of the teeth, and in their support in normal function. They consist of the enamel, dentin, cementum, pulp, peridental membrane, alveoli of the jaws, and gums or gingivæ.

Deciduous dentition.

It is interesting to know that the baby or deciduous teeth begin their formation during fœtal life. The crowns of the two upper and two lower deciduous incisors are almost completely formed when the baby is born. There are 20 teeth in a deciduous set, 10 upper and 10 lower. Each jaw has 4 incisors, 2 canines, and 4 molars. While these teeth are being used for mastication the permanent teeth are forming in the jaw just below them. As the crowns of the permanent teeth grow the roots of the baby teeth are resorbed which accounts for the fact that, when shed normally, baby teeth do not have roots.

Permanent dentition.

There are 32 teeth in the normal permanent set, 16 in each jaw as follows: 4 incisors, 2 canines, 4 premolars or bicuspids, and 6 molars. In the average mouth the third molars often fail to erupt and make their way through the gum and so do not take their normal working occlusion. This does not decrease the efficiency of the masticating organ.

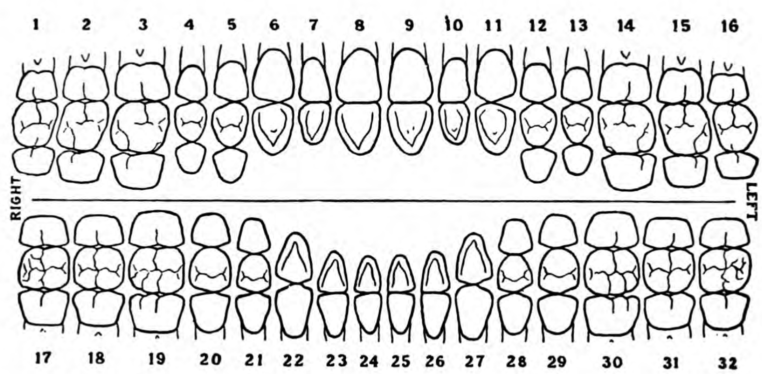

FIGURE 113.—United States Navy method of numbering teeth.

In the Navy, for the purpose of uniformity of records, the teeth are numbered from 1 to 32, beginning with the upper right third molar and continuing to the left side of the upper jaw, the third molar there being number 16, dropping to the lower right third molar for number 17 and continuing around the lower jaw to the left, the third molar there being number 32 (fig. 113).

The teeth.

Each tooth is usually considered to consist of two main parts, the *crown* and the *root*, which are connected by a third, the *neck*. The crown is that part of a tooth which projects above the gum and is the masticating part of

a tooth. The shape of the crown varies in the different teeth and on the masticating surface of the molars and premolars are from two to five rounded prominences called *tubercles*, or *cusps*, which are separated by grooves. The **neck** is the faintly constricted part of a tooth between the crown and the root and it is surrounded, collar-like, by the gum. The **root** is that part of a tooth which is embedded in the *alveolus* of the maxillæ or mandible, supports the crown, and is designed to withstand the forces of mastication. The end of the root is called the *apex* and through an opening in it the nerve and blood supply enter the tooth. The number of roots on a tooth varies according to the amount of work done by it in mastication, the molars and premolars, or grinding teeth, therefore having two or three roots while the incisors, or cutting teeth, and the canines have but one. The **alveolus** is the cavity or socket in the maxillæ and the mandible which receives the root or roots of a tooth. It varies in size and depth according to the tooth whose root or roots it contains, and is lined with the *peridental membrane* which also covers the root.

When a tooth is cut in half vertically through the center (fig. 114) a cavity will be found in the crown and center of each root which connects with the opening in the apex. The larger part of this cavity in the crown and neck is called the *pulp cavity*, the long, slender part in the root is known as the *root canal*, and both are filled with a soft, loose connective tissue, the *dental pulp*, which contains the blood vessels and nerves of the tooth. In the molar and premolar teeth the pulp cavity is extended into the bases of the cusps and in the incisor teeth it extends out toward the angles of the crown.

In structure, a tooth is composed of both hard and soft tissues, the hard tissues being the *enamel*, *dentin*, and *cementum* and the soft the *dental pulp* and *peridental membrane*. Surrounding the neck of the tooth and covering the alveolus is a firm tissue called the *gingiva*, or *gum*.

Enamel is the white, glistening substance which covers the crown of the tooth and extends to the commencement of the root. It is thickest on the masticating surface of the crown and gradually thins as it approaches the neck where it is slightly overlapped by the cementum. Enamel is the hardest, most compact, and most resistant substance in the body and is composed of "slender, prismatic rods, irregularly five or six sided," which lie parallel with one another and, generally speaking, at right angles to the junction of the enamel with the dentin, being vertical on the summit of the crown and horizontal on the sides. The enamel rods are held together by a cementing substance which, like the rods, is composed of inorganic salts. According to Noyes the chemical composition of enamel is as follows:

	Per cent
Calcium phosphate and fluoride	89.82
Calcium carbonate	4.37
Magnesium phosphate	1.34
Other salts	.88
Organic matter	3.39
Fat	.20
Total	100.00

Dentin is the hard, yellowish-white substance which composes the greater portion of the tooth and is a modification of osseous tissue but from which it differs in structure. It is highly elastic and very tough, gives strength to the tooth, and consists of the *matrix*, into which fine fibrils of the dental

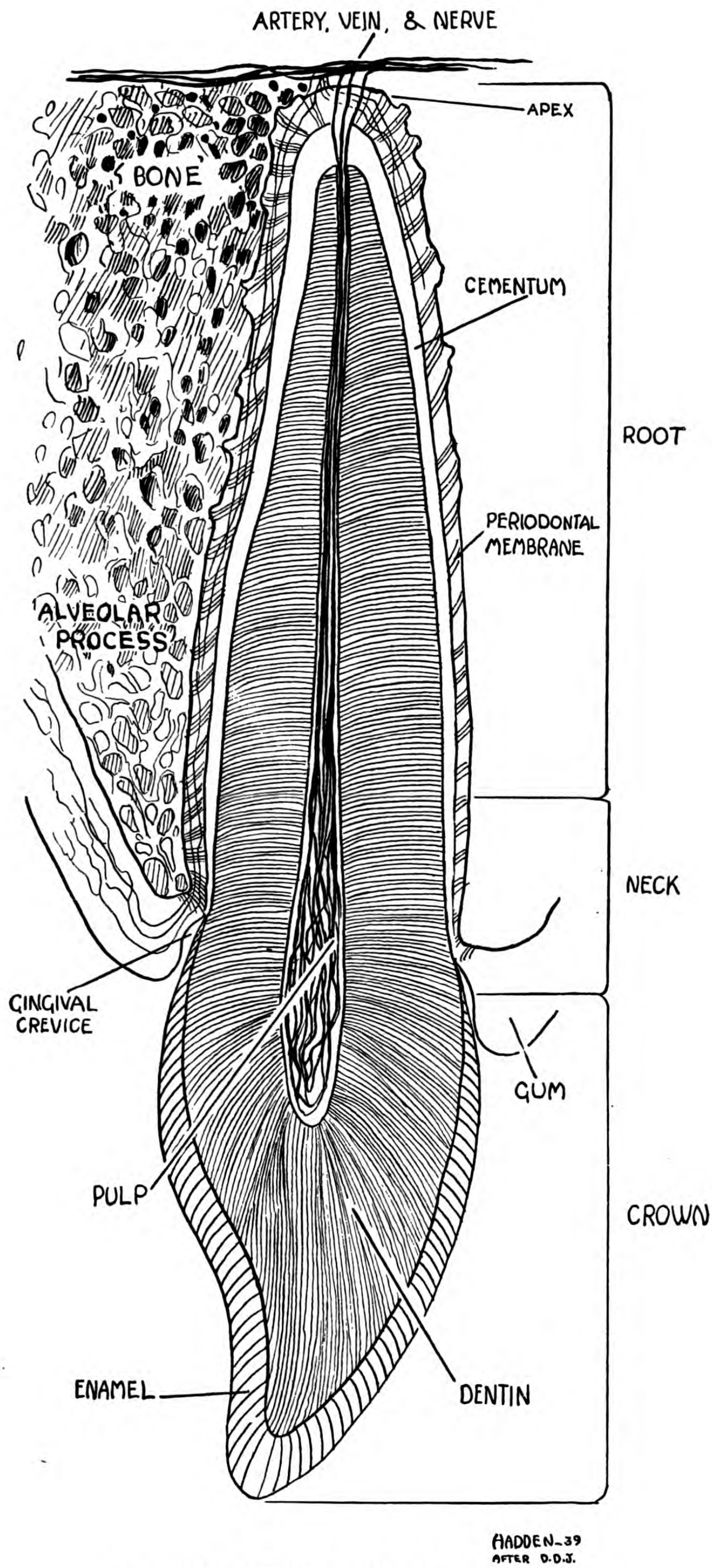

FIGURE 114.—Vertical section of an incisor tooth.

pulp extend, and the *dentinal tubules* which traverse the matrix everywhere, whose walls are called the *dentinal sheaths of Newman*, and which contain the *dentinal fibers*, prolongations of the outermost cells of the dental pulp. According to Noyes the chemical composition of dentin is as follows:

	Per cent
Calcium phosphate and fluoride	66.72
Calcium carbonate	3.36
Magnesium phosphate	1.08
Other salts	.83
Organic matter	27.61
Fat	.40
Total	100.00

Cementum is the outer covering of the root of the tooth and begins as a very thin layer slightly overlapping the enamel at the neck and increasing in thickness as it nears the apex which is composed entirely of this substance. In structure and chemical composition it closely resembles bone and is formed around the root in layers which are deposited one on top of another. To it the fibers of the peridental membrane are attached thereby securing the root in the alveolus.

The **dental pulp** which occupies the pulp cavity and the root canal is composed of branched connective tissue cells whose branches anastamose and form a fine network within which is a jelly-like material and the blood vessels and nerves of the tooth. The outermost cells of the dental pulp are known as *odontoblasts*, whose function is to form dentin and which have processes that are prolonged and extend into the dentinal tubules in the dentin. The function of the nerves in the dental pulp is largely sensory and they respond to thermal and chemical changes and traumatic irritation. A very rich blood supply is necessary for the normal functioning of the pulp and consequently there are numerous blood vessels in it which form a capillary plexus within the odontoblasts.

The **peridental membrane,** also called the *periodontal membrane* and *alveolar periosteum*, is a layer of fibrous, nonelastic connective tissue which lines the alveolus and covers the root of the tooth. It is continuous with the fibrous structure of the gum and its fibers are attached on one side to the cementum of the root and on the other to the bone of the alveolus. The root is thus firmly fixed in the alveolus and may be said to rest in the peridental membrane as if in a hammock. It is obvious that the peridental membrane permits a very slight movement of the teeth in mastication. When this membrane is diseased the tooth movement becomes excessive and the tooth is loose or feels high. Pain will be experienced when the tooth feels high.

The gingiva, or gum, is the soft but firm tissue surrounding the neck of the tooth. It is a dense fibrous tissue continuous with the peridental membrane lining the alveolus and is covered with a smooth and vascular mucous membrane. On each tooth there is a shallow trough or crevice which is formed by the free margin of the gum and is called the *gingival trough* or *crevice*. The gum is held snugly to the tooth by circular fibers which act as elastic bands, is firm to the touch, and normally is a pale pink in color. Damage done to the gum during a prophylaxis contributes to a breaking down of the tissues composing the gum, and when the tone (elastic effect) of the gum is lost, food has a tendency to fill the gingival trough. The pressure exerted by the packing of food in the trough, together with the activity of the bacteria incorporated in the food, leads to an inflammatory condition of the gums called *gingivitis* when

in the acute stage and *pyorrhoea* when in an advanced and chronic stage. Another factor of importance in the health of the gum is the hard incrustation of mineral and organic matter which forms on the teeth and sometimes on the gum called *tartar* or *calculus*. Tartar is of two kinds, *salivary calculus*, which forms above the gum, and *serumal calculus*, which forms below the gum line. If the teeth are not kept free from tartar formation, the gums become inflamed, recede, and are subject to attacks by dangerous organisms.

The oral cavity.

In considering the mouth from the standpoint of cleanliness, it must be remembered that more types of bacteria are to be found there than in any other part of the body. In the vernacular it might be said that the mouth is a "club house" for bacteria, as the presence of food, and the air, moisture, and temperature in the mouth make conditions there most favorable for their growth. All bacteria found in the mouth are not harmful to man, and the body's resistance to the invasion of bacteria is its natural protection against these lower forms of life.

The harmful bacteria are the ones that are of most interest to the dentist and physician in their practice of the healing arts, and they, as well as the conditions they produce, can be recognized. Before any treatment is given the bacteria present should be identified so that measures to combat them may be taken. It is with this thought in mind that the following oral conditions are briefly described so that the semiskilled person may render first aid in the absence of a dental officer.

It should be remembered that it is important to prevent the spread of infectious bacteria from one individual to another and when, through failure to properly cleanse the hands or to sterilize instruments such transference of bacteria occurs it is known as *cross infection*. The spread of disease in this manner is the result of carelessness or ignorance and is inexcusable and culpable. Bacteria from the mouth of a patient may be transferred to the operator or to another patient unless the rules of asepsis and sterility are observed. Numerous cases are on record of syphilitic lesions appearing on the fingers of dentists and physicians and infections of this type were quite frequent before the advent and use of rubber gloves.

Special attention should be paid to the fact that many diseases of the mouth are very contagious and an individual may carry very dangerous bacteria without exhibiting any of the symptoms of the disease. If, in some manner, such bacteria are transferred from the person carrying them to another, serious complications may arise through the appearance of the disease in the person to whom the bacteria have been transferred. It is therefore of paramount importance that the fingers and all instruments and materials used in a patient's mouth should be absolutely clean. It is impracticable and unnecessary to have instruments sterile for dental operations except in those that are of a surgical nature, but they must be clean, that is, they must have been cleaned and sterilized since they were used in the mouth of a previous patient. Briefly, all instruments used in an operation must be washed and sterilized following their use. They should be thoroughly washed, then boiled for 15 minutes in an instrument sterilizer, dried with a clean towel, and handled as little as possible while stowing away in the instrument cabinet and before being used again in a mouth. Hospital corpsmen must realize how important it is to be clean in the handling of dental instruments and materials and should exercise care in disposing of waste materials. There is but little possibility of cross infection if this routine is followed.

Changes in the structure of the teeth may result from the action of putrefactive agents in particles of food lodged in the spaces between and around the teeth and also from the presence of various bacteria. In addition to causing decay of the teeth, these agents may cause irritation of the gums. The prevention of these changes is considered a part of dental first aid.

Decay of the teeth and irritation of the gums to a large degree can be prevented by attention to and the execution of a few simple principles. "A clean tooth never decays" is a well-known slogan, which, while not true in its entirety, has so much in its favor that it is well worth keeping in mind.

Decay occurs most frequently in places which are not kept clean. The surfaces of the teeth which are seen when the mouth is opened are kept clean and polished, to a great extent, by the cheeks on one side and the food and tongue on the other. The spaces between the teeth, however, are not kept free from debris by the above means or by rough food, which well might serve that purpose. Attention is, therefore, to be directed to these spaces. In the usual procedure of brushing the teeth the surfaces which are kept clean by the tongue, food, and cheeks are the only ones which also are scrubbed with the toothbrush. The spaces which are vital in the prevention of decay of the teeth as a rule are not cleansed. To clean these spaces it is necessary to get in between the teeth and remove from these spaces food debris, bacteria, and the products of decomposition. Several methods for the attainment of this result have been advocated, among which the use of dental floss has been the most satisfactory. By its use the individual may remove much of the offending material. A much simpler and more efficient method is that in which a small brush with the bristle tufts not set too closely together is laid against the neck of the teeth, bristle ends toward the teeth, and the bristles gently worked into the spaces between the teeth with a sort of oscillating motion. This is to be repeated several times in each vicinity. To help keep tone in the gums the brush should be passed briskly over all surfaces of mucous membrane in the mouth, including the tongue. Using salt on the brush or salt water is a good routine practice, though no objection exists to the use of the most popular dentifrices. Brushing the teeth and gums four times a day, upon arising and after each meal, is given as ideal, but most persons must be content with a night and morning brushing.

EMERGENCY DENTAL TREATMENT

The most common dental conditions for which a dental technician or hospital corpsman may be called upon to render first-aid treatment when the services of a dental officer are not immediately available, will now be described. The descriptions of the symptoms and of the first-aid treatment are necessarily brief and are intended to serve only as a reference to assist the hospital corpsman in diagnosing and treating the dental conditions with which he has to deal. Hospital corpsmen should never attempt to administer dental treatment beyond the simplest measures which will relieve pain or render first aid in the event of an accident.

Painful cavities.

Decay or simple caries is a localized cavity containing decalcified tooth substance. Simple caries is usually painless except when subjected to thermal changes (usually cold), sweets, or pressure from some foreign material such as food within the cavity. The offending cavity may be seen by inspection of the mouth, it may be discovered through exploration with instruments, and often can be located only by transillumination especially when the enamel

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apparently is intact and the cavity is within the enamel. Such cavities are often disclosed by the enamel breaking off while eating.

Food and soft debris in the cavity should be gently removed with suitable instruments, the cavity washed with warm water, dried with small pellets of cotton, and a small pellet of cotton moistened with dentalone or eugenol placed in the cavity. If temporary stopping is available it may be heated and used to fill the remainder of the cavity. If desired the cavity may be filled with a paste made by mixing zinc oxide and eugenol on a slab to a fairly thick consistency. This paste hardens when it comes into contact with saliva, and if mixed to a putty-like consistency will serve as a temporary filling material for several weeks, and in the meantime will exert a sedative action on the tooth substance.

Occasionally a patient points to a perfectly sound tooth and complains that it aches. It is possible, of course, that nerve trouble does exist in that tooth, but it is always advisable to look at the other teeth on the same side of the jaw, both above and below, for a cavity, and if one is found, to cleanse it and apply a sedative, which will often relieve the pain in the tooth pointed out by the patient. Such pain in sound teeth is termed reflected pain.

Dental pain resulting from inflamed pulp.

The most common type of severe dental pain is toothache from an inflamed pulp which has become infected through a cavity in the tooth. This infection, with the attending inflammation and congestion, compresses the sensitive pulp tissue against the unyielding sides of the pulp cavity. The pain is apt to be sharp and lancinating, tends to increase on lying down, and is accentuated by temperature changes, particularly cold. The tooth is not noticeably tender to percussion (light blows struck with the handle of an instrument), and does not strike opposing teeth first when bringing the teeth together. Food and soft debris should be gently removed from the cavity with suitable instruments, the cavity washed with warm water, dried with small pellets of cotton, and a small pellet of cotton moistened with dentalone or eugenol, first touched to another piece of cotton to remove excess fluid, inserted into the cavity. The pellet should be small enough to go into the tooth and leave a portion of the cavity unfilled. Then take another piece of cotton large enough to fill the remainder of the cavity, dip this into compound tincture of benzoin or into sandarac varnish, remove the excess as above, and pack lightly over the sedative dressing. The benzoin or sandarac varnish on cotton will form a gummy, impervious mass when it comes into contact with saliva, thus tending to prevent dissipation of the medicament, will protect the pulp from temperature and pressure changes and will keep out foreign material. This treatment should be renewed every day or two until dental attention is available.

Alveolar abscess.

If the treatment previously outlined fails to afford relief the pain probably is caused by a pulp which is partially or wholly putrescent, as a result of which gases have formed which are exerting pressure through the root canal into the area around the apex. This forces bacteria and their toxins into the tissues at the end of the root and sets up an inflammation in the structures surrounding the root apex. As this inflammation is outside of the tooth in the alveolus, any medicament applied to the tooth or in the cavity will likely fail to afford relief. The pain will continue until drainage is naturally or artificially established. This type of toothache (alveolar abscess) requires the services of a dental officer to establish drainage through the root canal

or through the soft tissues and alveolar wall to the site of the abscess. When swelling becomes apparent pain usually ceases, and the swelling indicates an opening through the tissues has been made by the pus working its way to the surface. Heat may be locally applied on the face.

Digital examinations of the tissues of the mouth should be made at intervals to determine if a point of fluctuation has developed; when this is found an incision should be made through it directly toward the bone in the direction of the apex of the tooth for the evacuation of pus. Twenty-four to seventy-two hours may elapse between onset of pain and the appearance of swelling. Sedatives may be administered for the relief of pain pending the appearance of the swelling.

Gum abscesses.

These small abscesses are commonly called gum-boils, are frequently present and appear as small pimples or openings on the gums. This condition, as a rule, is painless, but by no means should it be neglected as in most cases it indicates the presence of a dead nerve in a nearby tooth. Gum-boils should receive professional attention at the first opportunity in order that the health of the individual may not be menaced.

Inflammation of lower third molar regions.

The lower third molar teeth (wisdom teeth) often are the cause of pain and swelling during their eruption. Upon looking into the mouth toward the angle of the jaw and just back of the last tooth, occasionally a part of a tooth may be seen coming through the gum with swelling and redness in the vicinity. To relieve this condition, wrap a small instrument or blunt probe firmly with a thin layer of cotton, dip this in half-strength tincture of iodine and gently force between the gum and tooth, working it carefully around the crown of the tooth. This simple treatment will sometimes result in an evacuation of a small amount of pus and relief will be afforded. The patient should be instructed to hold salt water, as hot as can be borne, in the mouth, forcing it back and forth over this area. This should be repeated frequently. Many times this area becomes infected with Vincent's micro-örganisms and treatment in these cases should be watched carefully for any spread of the infection. Using a 10-per cent solution of arsphenamine in glycerin, carry the solution gently around the tooth and under the gum on a probe wrapped with cotton. The mouth should be sprayed with a warm solution of sodium perborate or a half-strength solution of hydrogen peroxide.

As a pocket is usually formed distal to these teeth, it is advisable in many cases to drain the pocket, which is done by lightly placing a very small piece of iodoform gauze in the pocket, without pressure. This will maintain drainage and act as an antiseptic and deodorant until the patient can be seen by a dental officer.

Postoperative treatment for hæmorrhage following extraction of teeth.

Hæmorrhage may occur from a few hours to several days following the extraction of a tooth. It may originate from a socket or from the surrounding gum tissue. The origin of the bleeding must be determined and treatment applied in that area. The best means of controlling hæmorrhage is pressure, and if bleeding occurs from a socket it should be packed with gauze. The socket is first syringed with warm water to dislodge the blood clot and a strip of gauze saturated with epinephrine or thromboplastin is firmly packed into the socket until it is filled. Several gauze napkins, 6 by 6 inches, may

be folded to produce a pack of appropriate size which, when placed over the socket and between the adjacent teeth, will exert a firm pressure when the jaws are closed. Pressure must be maintained and the compress should not be disturbed for at least 30 minutes. If bleeding persists the treatment should be repeated. The patient should be instructed to avoid all excitement and to remain throughout the day in a sitting or reclining position. The jaws may be held closed by means of a Barton bandage. Sedatives may be given but stimulants should be avoided.

Postoperative treatment for pain following the extraction of teeth.

It occasionally happens that a day or more after the extraction of teeth severe throbbing pain occurs in the socket from which the tooth has been removed. This condition, known as "dry socket," indicates that a normal blood cot has failed to form and the socket is empty or is filled with debris. The socket should be gently cleansed by irrigation with warm saline or mild antiseptic solution and a small piece of plain or iodoform gauze moistened with dentalone, eugenol, or coated with dental-analgesic paste very gently inserted in the socket, taking great care not to exert pressure by packing in the gauze. Some relief should be experienced immediately but the pain and discomfort may persist for several days. The irrigation and gauze medication should be renewed daily. If a rise in temperature is observed and the patient seems very ill, osteomyelitis may be suspected and the patient should be taken to a medical officer immediately.

Vincent's infection, oral, or trench mouth.

The symptoms of this disease vary according to the degree of virulence of the infection and the resistance of the patient. The patient usually complains of pain and discomfort and bleeding of the gums when eating or brushing the teeth. It is characterized by a very red, inflamed appearance of the gums about the teeth, and a film of deadened, white or grayish tissue over the gums and between the teeth which bleeds readily when touched. The condition may be acute with considerable pain and discomfort or it may be less acute with only a thin line of red, inflamed tissue about the teeth, and the grayish-white film noticeable principally between the teeth with very little or none on the gums. In general this disease exhibits a dirty, grayish membrane covering shallow ulcers, with a distinctive, foul breath and excessive bleeding.

Vincent's infection is a highly contagious disease and its spread throughout a group of men may be very rapid if strict precautions are not instituted. Mess gear and all items which might come in contact with the mouth secretions must be sterilized immediately after use and before being washed. The sterilization should be done by boiling, or by sterilizing with steam. It is advisable that mess gear be washed and handled by the patient and kept apart from other mess gear throughout the treatment. Measures should be instituted to insure that this is done, and the patient warned that the disease may be transmitted by anything which comes in contact with the mouth, as pipes, tags on tobacco bags, drinking cups, etc. Refer to appendix D, Manual of the Medical Department for further information concerning this condition.

The treatment consists in the gentle application of medicaments which will destroy or reduce the causative organisms. No one method of treatment is effective for all cases. One level teaspoonful of sodium perborate dissolved in half a glassful of warm water as a mouth wash, prepared freshly for use every 4 hours, has been found effective in many cases. The solution of sodium perborate, however, in some instances causes additional irritation of oral tissues and this fact should be borne in mind.

Equal parts of peroxide of hydrogen and warm water also may be used as a mouth wash, and should be retained in the mouth for at least 2 minutes in order to get the benefit of the oxidizing action.

Another treatment is the application several times daily of a 10 per cent solution of arsphenamine in glycerin to all inflamed surfaces, allowing it to remain in contact several minutes and then rinsing the mouth with warm water. When applying arsphenamine solution place cotton rolls or absorbent cotton in the mouth to protect the cheeks and tongue while the medicament is being applied and while it remains in the mouth. The patient should be referred to a dental officer upon the first available opportunity.

Symptoms and treatment for fractures of the jaw.

Fractures of the jaws exhibit the symptoms of fractures in other bones and in addition there may be an irregularity in the line of occlusion of the teeth. As in other fractures, reduction and immobilization are indicated. If teeth are present they will serve as the best guide for proper reduction and immobilization, the teeth of one jaw serving as a splint for the other.

The bandage type of splint is useless as a permanent method of fixation and dental assistance should be secured as soon as practicable. As a first-aid measure the Barton bandage is not suitable for fractures of the lower jaw though it may be useful in fractures of the upper jaw. The bandage turn in the front of the chin is the objectionable feature of the Barton bandage for fractured mandibles; this turn may be omitted by making a figure-of-eight modified Barton passing under the chin, over the head and down back of the occiput, and repeating six or eight times, which will serve as a temporary support for the mandible. As a rule if the bandage is tight enough to serve as a splint it is too tight for normal circulation. The mouth should be kept clean and liquid diet administered.

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CHAPTER IV

Section 1.—MATERIA MEDICA AND THERAPEUTICS

Many of the substances used in the treatment of disease are obtained from the animal, vegetable, and mineral kingdoms. These substances generally are spoken of as medicines, commonly termed drugs, and in studying them it is necessary to consider their source, composition, physical characteristics, chemical properties, preparation and administration, and physiological and toxicological action. The science which treats of the substances used as medicines is **materia medica.**

That particular science which relates to the properties of medicinal substances and the application of remedial agents in the treatment of disease is known as **therapeutics.** In addition to the use of drugs as remedial agents, electricity, water, serums and vaccines, light rays, heat, physical, mechanical, and operative measures, and hygienic agents are employed for curative purposes. Therapeutics is divided into three classes known as *rational,* which is based upon known laws of the remedies and the diseases; *empirical,* based entirely on the results of clinical observation and experience, and *general,* when remedial agents other than drugs or medicines are used.

Medicines may be divided into two general groups—*stimulants,* which increase the functional activity of the body or of any organ or tissue, and *sedatives,* which lessen or reduce the functional activity and, according to their composition, are inorganic or organic.

The various preparations of drugs or the different forms in which they may be used and the names given to substances of vegetable origin are discussed in the chapter on Pharmacy.

Medicinal substances usually are described according to their actions and effects on the body or its organs and tissues, and following is a list of the terms used, with definitions of the therapeutic action of each.

Alteratives.—Medicines used to modify processes of nutrition so as to overcome morbid conditions.

Analgesics or anodynes.—Medicines used to allay pain.

Anæsthetics.—Medicines used to produce local or general insensibility.

Anaphrodisiacs.—Medicines which depress the sexual appetite and function.

Anhydrotics.—Medicines which are used to diminish perspiration.

Antacids.—Medicines used to neutralize acid in the stomach and intestine.

Anthelmintics.—Medicines used to destroy or expel intestinal worms.

Antidotes.—Medicines or agents which act upon poisons in such a manner as to alter their composition, rendering them less poisonous, and so preventing their toxic action from being exerted upon the organism.

Antiemetics.—Medicines used to arrest vomiting.

Antiperiodics.—Medicines used for the relief of periodically recurring diseases, such as malaria.

Antiphlogistics.—Medicines or agents which reduce or dissipate inflammation.

Antipyretics.—Medicines used in the reduction of body temperature in fevers.

Antiseptics.—Substances which have the power of preventing the growth and development of bacteria.

Antisialics.—Medicines or agents which reduce the secretion of the saliva.

Antispasmodics.—Medicines used for the relief of nervous irritability and minor spasms.

Antisyphilitics.—Medicines used in the treatment of syphilis.

Aperients.—Mild cathartics.

Aphrodisiacs.—Medicines which stimulate sexual appetite and function.

Aromatics.—Medicines characterized by a fragrant or spicy taste and odor and which stimulate the gastrointestinal mucous membrane.

Aromatic bitters.—Medicines which unite the properties of the aromatics and the simple bitters.

Astringents.—Medicines which produce shrinkage of mucous membranes or raw tissues, decreasing the amount of exudation from them.

Bitters, simple.—Medicines which have a bitter taste and have the effect of stimulating the gastrointestinal mucous membrane without affecting the general system.

Cardiac depressants.—Medicines used to lessen the force and frequency of the heart's action.

Cardiac stimulants.—Medicines used to increase the force and frequency of the heart's action.

Carminatives.—Medicines which aid in the expulsion of gas from the stomach and intestine by increasing peristalsis, stimulating circulation, etc.

Cathartics.—Medicines which increase or hasten the evacuation of the intestine. They are classified according to their power, as follows: *Laxatives* or *aperients, simple purgatives, drastic purgatives, saline purgatives, hydrogogues, cholagogues.*

Cerebral depressants.—Medicines which lower or suspend the functions of the higher brain after a preliminary stage of excitement.

Cerebral excitants.—Medicines which, if given in proper doses, increase the functional activity of the cerebrum without causing any subsequent depression or suspension of the brain function.

Correctives.—Medicines which are used to correct or render more pleasant the action of other remedies, especially purgatives.

Deliriants.—Medicines which excite the functional activity of the higher brain to such a degree as to disorder the mental faculties and produce intellectual confusion, loss of will power, delirium, and even convulsions.

Demulcents.—Substances usually of oleaginous or mucilaginous natures, which soothe and protect the parts to which they are applied.

Deodorants.—Substances which destroy or hide foul odors.

Diaphoretics.—Medicines which produce increased excretion of sweat.

Digestants.—Ferments and acids which have the power of aiding in the solution of food.

Disinfectants.—Substances which have the power of destroying disease germs.

Diuretics.—Medicines which increase the secretion of the urine.

Emetics.—Medicines which produce vomiting.

Escharotics or **caustics.**—Substances which destroy the tissue to which they are applied and produce a slough.

Expectorants.—Medicines which increase bronchial secretion.

Febrifuges.—Medicines which lessen fever.

Hæmostatics.—Medicines which arrest hæmorrhages (usually applied to internal bleeding).

Hepatic stimulants.—Medicines which increase the functional activity of the liver cells and the amount of bile secreted.

Hypnotics.—Medicines which, in the proper doses, produce sleep without narcotic or deliriant effects.

Irritants.—Substances which, when applied to the skin, produce more or less vascular excitment. When employed to excite a reflex influence on a part remote from the place of application they are termed *counterirritants. Rubefacients*, the mildest of this group, cause redness (congestion) of the skin. *Vesicants* or blistering agents produce decided inflammation of the skin and the accumulation of serum between the epidermis and the derma.

Motor depressants.—Medicines which lower the functional activity of the spinal cord and the motor apparatus, and in large doses paralyze them directly.

Motor excitants.—Medicines which increase the functional activity of the spinal cord and motor apparatus, producing heightened reflex excitability, disturbances of motility, and when given in large doses, tetanic convulsions; their ultimate effect being motor paralysis from overstimulation.

Mydriatics.—Medicines which cause dilation of the pupil.

Myotics.—Medicines which cause contraction of the pupil.

Narcotics.—Drugs which "lessen the relationship of the individual to the external world." At first excitant to the higher brain they soon cause profound sleep, characterized by increasing stupor, and if the dose is sufficient, coma, insensibility, and death by paralysis of the nerve centers which control organic life.

Neurotics.—Medicines which act upon the nervous system.

Nutriants.—Medicines which modify the nutritive processes.

Nutrients.—Substances which give nourishment to the system.

Parasiticides.—Medicines which destroy the various animal and vegetable parasites.

Prophylactics.—Medicines which prevent the taking or the development of disease.

Pulmonary sedatives.—Medicines which relieve cough and dyspnœa by lessening the irritability of either the respiratory center or the nerves of respiration.

Purgatives.—Medicines which produce free evacuation of the bowels.

Refrigerants.—Medicines which impart a sensation of coldness and thereby allay thirst and restlessness.

Renal depressants.—Medicines or agents which lessen the secretion of the urine.

Respiratory depressants.—Medicines which lower the action of the respiratory center.

Respiratory stimulants.—Medicines which exalt the function of the respiratory center in the medulla oblongata, quickening and deepening the breathing.

Sialogogues.—Medicines which increase the secretion of the salivary glands (the secretion of the mouth).

Soporifics.—Hypnotics.

Specifics.—Medicines which have a direct curative influence on certain individual diseases.

Stomachics or gastric tonics.—Medicines which increase the appetite and promote gastric digestion.

Styptics.—Medicines or applications to control external hæmorrhages.

Tæniacides.—Medicines which kill tapeworms.

Tonics.—Medicines which augment gradually and permanently the strength and vital activity of the body or its organs, increasing the vigor of the entire system.

Vermicides.—Medicines which kill intestinal worms.

Vermifuges.—Medicines which cause the expulsion of intestinal worms.

Vesical sedatives.—Medicines which lessen the irritability of the bladder, decreasing the desire to urinate, and relieving vesical pain and tenesmus.

Vesical tonics.—Medicines which increase the tone of the muscular fibers in the wall of the bladder, consequently the power for contracting and expelling the urine is increased.

Administration of medicines.

The normal or adult dose of medicine is based upon the condition that the individual must be 24 years of age and weigh about 150 pounds. Persons under 24 and over 60 years of age require smaller doses in proportion.

In computing the dose for persons under 24 years of age, the following rules are applicable. *Young's rule* directs that the age of the person be taken as the numerator of the fraction and the age plus 12 as the denominator. Thus for a child 3 years old 3 would be the numerator and 3 plus 12, or 15 the denominator, $\frac{3}{3+12}=1/5$ of adult dose. *Cowling's rule* directs that the age at next birthday be taken as the numerator of the fraction, and 24 (the age of the adult) as the denominator of the fraction.

In using either of these rules it should be remembered that children usually require larger doses of purgatives, diaphoretics, and diuretics, and smaller doses of narcotics than is called for.

When the dose of a drug is spoken of, the amount necessary to produce a medicinal effect in an adult, or the *therapeutic dose*, ordinarily is meant. The doses given in the Pharmacopœia and the National Formulary are the average therapeutic doses. In addition, there are the *minimum dose*, the smallest quantity which can produce a medicinal effect, the *maximum dose*, the largest quantity which can be given without probable poisoning or harmful effects, the *toxic dose*, which is the amount producing poisoning, and the *lethal dose*, which is the smallest dose that will produce death. The average dose is the one usually learned. In the administration of medicines there are many factors which affect the dose, the method of administration, and the frequency of the doses. These conditions, briefly described, are:

1. **Age.**—Children (see preceding rules) and aged adults as a rule require less than the normal adult dose.
2. **Sex.**—Females require smaller doses than males.
3. **Race.**—Negroes usually require larger and Asiatics smaller doses than white people.
4. **Physical condition.**—Strong, burly patients require larger doses than weak patients.
5. **Temperament.**—Sanguine (ardent, cheerful, full-blooded) temperaments require smaller doses of stimulants than phlegmatic (heavy, dull, stolid, apathetic) temperaments.
6. **Idiosyncrasy.**—This is the peculiarity of constitution of individuals to react differently to drugs or other influences.
7. **Climate.**—People in warm climates, as a rule, require smaller doses of purgatives.
8. **Occupation.**—Men working out of doors at hard labor will require larger doses than those who sit at a desk all day.

9. **Habitual use.**—This modifies the dose by lessening the medicinal power of the drug, and the dose must be increased greatly to obtain a medicinal effect (opium, morphine, and cocaine users).

10. **Disease.**—Disease conditions modify the dose, as in tetanus and peritonitis, when larger doses of narcotics are tolerated.

11. **Form of the drug.**—This controls largely the rate of absorption, as all substances must be reduced to solution before entering the circulation.

12. **Time of administration.**—Drugs given before a meal are more quickly absorbed than those administered upon a full stomach.

13. **Mode of administration.**—As a rule drugs administered hypodermically are used in much smaller quantities.

14. **The frequency of administration.**—It is obvious that the dose of a drug is less if administered frequently than if administered at long intervals.

Medicinal substances may be introduced into the circulation by any one of the following methods:

By mouth.—This is the most common of all methods and is usually the most desirable except when very rapid action is required.

Subcutaneously.—This method, in which medicines are injected under the skin, frequently is used when rapid action is desired or when the stomach will destroy the virtue of the drug if given by mouth.

By rectum.—This method is used when it is impossible to administer drugs by mouth because of vomiting, semi or unconsciousness, delirium, or certain diseases of the gastrointestinal tract.

By inunction.—This consists of applying ointments or oily combinations to the skin and rubbing them in.

Intravascularly or intravenously.—By this means preparations of drugs are introduced directly into a vein.

Inhalation.—By this method medicated vapors or drugs, such as ether or chloroform, are inhaled into the respiratory system.

Fumigation.—In this manner easily volatilized drugs are applied directly to the skin, except the head, by means of a vapor bath.

By hypodermoclysis.—This consists of introducing solutions of saline into the loose tissues about the breasts, abdomen, or below the scapulæ.

Intramuscularly.—This consists of injecting readily absorbable, sterile preparations of drugs into the muscle tissue.

In order to obtain the greatest benefit of their action, as a general rule, *bitters* are administered before meals; *alkalies*, if to increase the flow of gastric juice, before meals; if to neutralize the acidity of the gastric juice, after meals; *acids*, one-half to one hour before meals; *laxatives*, before retiring; *active cathartics*, the first thing in the morning; *hypnotics*, from one-half to two hours before sleep is required; *slowly acting drugs* (digitalis), at long intervals; *rapidly acting drugs* (ammonia, nitroglycerin) at very short intervals; such drugs as *mercury*, *arsenic*, *iron*, *iodides*, not on an empty stomach, but from one-half to one hour after meals.

Following is a brief description of drugs in common use, and on the Naval Medical Supply Table, grouped in the various chemical classes to which they belong.

INORGANIC MATERIA MEDICA

The official Latin and English titles, the common names or synonyms, and the symbolic formulas, if any, appear in **black face type** in the following descriptions of medicinal substances. Those official in the Pharmacopœia are indicated by the letters U. S. P. following the names, those recognized by the National Formulary by the letters N. F., and those in New and Nonofficial Remedies by the letters N. N. R.

Iodine and its preparations.

Iodum, Iodine, I, U. S. P.—Iodine contains not less than 99.5 per cent of I. Preserve iodine in glass bottles closed with stoppers resistant to corrosion, and in a cool place, protected from light.

PROPERTIES: Heavy, grayish-black, brittle plates, having a metallic luster and a characteristic odor. One gram is soluble in 2,950 cc of water, in 12.5 cc of alcohol, in 80 cc of glycerin, and in 4 cc of carbon disulfide. It is freely soluble in chloroform, in carbon tetrachloride, and in ether, and is dissolved by aqueous solutions of iodides. Iodine unites actively with iron and other metals. In weighing iodine use a bone or rubber spatula, and paraffined paper on the scale pans. With starch paste iodine gives a deep blue color. Iodine stains may be removed from linen by the application of a solution of sodium thiosulfate.

SOURCE: Iodine is now obtained principally from the mother liquors obtained in the purification of crude Chili saltpeter (sodium nitrate). Some iodine is obtained from the ashes obtained by burning seaweeds. A new source of iodine is the brine issuing from the oil in petroleum oil-wells. In Chili saltpeter iodine occurs as sodium iodate mixed with sodium nitrate.

ACTION AND USES: *See* preparations of iodine. The antidote is starch paste.

Average dose: 0.01 Gm. or 1/6 grain.

Tinctura Iodi, Tincture of Iodine, U. S. P.—An alcoholic solution of iodine and potassium iodide. One hundred cc contains not less than 6.5 Gm. nor more than 7.5 Gm. of I, and not less than 4.5 Gm. nor more than 5.5 Gm. of KI. Preserve it in glass bottles, closed with stoppers resistant to corrosion, and in a cool place, protected from light.

PREPARATION: *See* U. S. P.

ACTION AND USES: It is applied externally as a counter-irritant, disinfectant, and parasiticide. It may be applied to any part of the body externally except the eye. An alcoholic solution (half strength) containing equal parts of the tincture and alcohol is employed in the disinfection of the skin before operations. It penetrates into the pores and acts as a powerful germicide. It should never be painted over a surface that previously has been washed with bichloride of mercury solution, because in the presence of the bichloride new compounds are formed which are intensely irritating, especially under a dressing, and blistering of the skin is liable to occur. To get the best germicidal results from tincture of iodine, it should not be applied to a surface wet with water. Internally tincture of iodine is used as an alterative. It acts as an irritating poison in large doses. *The antidote is starch paste or starchy foods, such as bread and mashed potatoes.* Iodine stains can be removed from linen with a solution of sodium thiosulfate.

Average dose: 0.1 cc or 1½ minims (diluted with water).

Tinctura Iodi Mitis, Mild Tincture of Iodine, U. S. P.—Mild Tincture of Iodine contains, in each 100 cc, not less than 1.8 Gm. and not more than 2.2 Gm. of I and not less than 2.1 Gm. nor more than 2.5 Gm. of NaI dissolved in 50 per cent alcohol. Preserve it in the same manner as Tincture of Iodine.

ACTION AND USES: This weak tincture is actively antiseptic and when applied to the abraded surface is not so painful as the strong tincture. The presence of iodides in both the strong and the weak tinctures improves their stability and increases their penetrability. With acetone iodine forms an irritating compound. A solution containing 1 cc of Mild Tincture of Iodine to 100 cc of 70 per cent alcohol is used as a local application in the treatment of trichophytosis (athlete's foot).

Liquor Iodi Compositus, Compound Solution of Iodine (Lugol's Solution), U. S. P.—Compound Solution of Iodine is a solution containing, in each 100 cc, not less than 4.5 Gm. and not more than 5.5 Gm. of I, and not less than 9.5 Gm. and not more than 10.5 Gm. of KI. Preserve it in glass bottles, closed with stoppers resistant to corrosion, and in a cool place, protected from light.

ACTION AND USES: It is given internally for the preoperative treatment of toxic goiter. It should be highly diluted with water, when given by mouth, to prevent gastric irritation.

Average dose: 0.2 cc or 3 minims.

Oxygen and its compounds with hydrogen.

Oxygenum, Oxygen, O, U. S. P.—It contains not less than 99 per cent of O by volume. For convenience it is usually supplied in compressed form in metallic cylinders.

PROPERTIES: A colorless, odorless, tasteless gas, which supports combustion more energetically than air. It is slightly soluble in water.

PREPARATION: Oxygen is separated from the air by extreme cold and high pressure. When liquid air is allowed to vaporize the nitrogen escapes first because of its greater volatility, and the gas that comes off last is nearly pure oxygen.

ACTION AND USES: It is employed to relieve difficult respiration as in pneumonia. It is administered by inhalation in the treatment of poisoning by carbon monoxide. It is used with nitrous oxide in anæsthesia to prevent cyanosis. When the oxygen tent is being used great care must be exercised to prevent persons entering the room with a lighted cigarette.

Aqua, Water, H_2O, U. S. P.—A clear, colorless, practically tasteless and odorless liquid. It has a *p*H of not less than 5.8 and not more than 8.3. Ordinary water contains in solution or suspension traces of salts, organic matter, and gases, varying in amounts with different localities. These impurities in limited amounts do not render water unfit for drinking purposes or for making pharmaceutical preparations containing some drugs, but their presence is objectionable in certain cases.

Aqua Destillata, Distilled Water, H_2O, U. S. P.—Water purified by distillation. It is a clear, colorless liquid, without odor and taste. It has a *p*H between 5.8 and 7.

Aqua Destillata Sterilisata, Sterilized Distilled Water, U. S. P.—It is freshly distilled water recently sterilized. *See* U. S. P. page 66. It should be used within 24 hours after sterilization when stored in stoppered containers.

Aqua Redestillata, Redistilled Water, Triple Distilled Water, U. S. P.—Redistilled water is free from nonvolatile matter and gases; also from microörganisms or other oxidizable matter. Redistilled water intended for intravenous use should be sterilized within 2 hours after its redistillation and should be preserved in a suitable manner against contamination. It should be used for intravenous use only on the same day it is sterilized. Hard, insoluble glass flasks previously rinsed with triple distilled water should be used for sterilizing triple distilled water. *See* Pyrogen, page 1650 of Remington's Practice of Pharmacy, eighth edition.

Nitrogen compounds.

Nitrogenii Monoxidum, Nitrogen Monoxide (Nitrous Oxide), N_2O, U. S. P.—It contains not less than 95 per cent by volume of N_2O. It is supplied in compressed form in metallic cylinders. It is a colorless gas, having a slight, characteristic odor and in aqueous solution a somewhat sweetish taste. It supports the combustion of many substances. One volume of the gas dissolves in 1.5

volumes of water under normal pressure and at 20° C. It is more freely soluble in alcohol than in water.

Action and Uses: It is a quick-acting anæsthetic, requiring only a few inhalations to produce unconsciousness. It is usually given mixed with oxygen.

Sulfur.

Sulfur Sublimatum, Sublimed Sulfur (Flowers of Sulfur), S, U. S. P.—It contains 99.5 per cent S.

Properties: A fine, yellow, crystalline powder having a faint odor and taste. It is insoluble in water and nearly insoluble in alcohol. It is soluble in carbon disulfide, ether, and in olive oil. It burns in air to form sulfur dioxide gas.

Action and Uses: Sublimed sulfur is not given internally. It is used in the preparation of Washed Sulfur.

Sulfur Lotum, Washed Sulfur, U. S. P.—It contains not less than 99.5 per cent of S. Washed sulfur is sublimed sulfur which has been treated with ammonia water. Ammonia water removes traces of arsenic and sulfuric acid which may be present in sublimed sulfur. After the removal of these impurities sulfur is fit for internal use.

Action and Uses: Used internally as a laxative in Compound Powder of Senna, U. S. P.

Average dose: 4 Gm., or 1 dram.

Sulfur Præcipitatum, Precipitated Sulfur, U. S. P.—It contains not less than 99.5 per cent of S.

Properties: A very fine, pale yellow, amorphous or microcrystalline powder, without odor or taste.

Action and Uses: The particles are lighter and more easily suspended than washed or sublimed sulfur. Ointments made with precipitated sulfur are smoother than those made with sublimed sulfur. It is used in making Sulfur Ointment, U. S. P. It is suitable for internal administration.

Average dose: 4 Gm., or 1 dram.

Unguentum Sulfuris, Sulfur Ointment, U. S. P.—It contains not less than 13.5 per cent and not more than 16.5 per cent of S.

Composition: Precipitated sulfur, 15 Gm., wool fat, 5 Gm., yellow wax, 5 Gm., white petrolatum, 75 Gm.

Action and Uses: It is used externally as a parasiticide against scabies; and in seborrheal diseases. When applied to the face it should be diluted with 5 parts of Unguentum, U. S. P.

Carbon.

Carbo Activatus, Activated Charcoal, U. S. P.—The residue from the destructive distillation of various organic materials, treated to increase its adsorptive power. When Carbo Ligni is prescribed, Carbo Activatus may be dispensed. Preserve Activated Charcoal in well closed containers.

Description: A fine, black, odorless, and tasteless powder, free from gritty matter. It is estimated that 1 cc of finely divided charcoal possesses a total surface of approximately 1,000 square meters.

Action and Uses: It is given internally as an adsorbent of gases in intestinal fermentation. It is used in pharmaceutical manufacturing as a decolorizing agent. It is one of the substances found in most all gas masks used in chemical warfare. (Chemical Warfare, Fries and West, p. 242.)

Average dose: 2 Gm., or 30 grains.

Carbonei Dioxidum, Carbon Dioxide, CO_2, U. S. P.—It contains not less than 99 per cent by volume of CO_2. It is supplied in compressed form in metallic cylinders.

DESCRIPTION: A heavy, odorless, colorless gas. The taste of an aqueous solution of the gas is faintly acid. One volume of carbon dioxide dissolves in about one volume of water. Carbon dioxide extinguishes a flame.

ACTION AND USES: It is a stimulant to respiration. It is added to oxygen in varying proportions, from 1 to 5 per cent carbon dioxide and from 95 to 99 per cent oxygen, for supplying artificial respiration and as a stimulant to the respiratory center. The proportion of carbon dioxide to oxygen must be carefully regulated because an excess of carbon dioxide causes death by asphyxia.

Boron.

Acidum Boricum, Boric Acid (Boracic Acid), H_3BO_3, U. S. P.—Boric acid contains not less than 99.5 per cent of H_3BO_3. Preserve it in well closed containers.

PROPERTIES: Colorless scales of a pearly luster, or crystals, or a white powder, slightly unctuous to the touch. It is odorless and is stable in the air. One gram is soluble in 18 cc of water, and in 18 cc of alcohol, and in 4 cc of glycerin. An aqueous solution is slightly acid to litmus paper.

ACTION AND USES: Boric acid is a mild antiseptic. Externally it is used as a dusting powder either alone or with diluents such as starch or talcum. An aqueous solution containing from 2 to 4 per cent is used as an eye lotion. Boric acid solution has caused death in infants when given internally by mistake.

Average dose: 0.5 Gm., or 8 grains.

Unguentum Acidi Borici, Boric Acid Ointment, U. S. P.—It contains not less than 9 per cent and not more than 11 per cent of H_3BO_3. Each 100 grams of ointment contains 10 Gm. boric acid, 5 Gm. wool fat, 5 Gm. white wax, and 80 Gm. white petrolatum.

ACTION AND USES: It is used as an emollient and protective on superficial wounds and abrasions. Its antiseptic properties are very slight.

Inorganic or mineral acids.

These compounds all contain hydrogen which is replaceable by metals forming salts, having a characteristic sour taste and corrosive action, and change the color of blue litmus to red. When acted upon by a base (alkali) they are neutralized and in turn neutralize the base, forming a salt and water. This is why an acid is used as an antidote for poisoning by a base, and a base as the antidote for acid poisoning. *An acid is defined as a compound of hydrogen with an electronegative element or radical.* Sulfur (S) is an electronegative element and when it is combined with hydrogen produces H_2S, hydrosulfuric acid; SO_4 is the electronegative sulfate radical, and when it is combined with hydrogen produces H_2SO_4, sulfuric acid. The strong inorganic acids should be handled with great care because they are very corrosive and poisonous. When given internally they should be highly diluted, and should be taken through a glass tube to prevent injury to the teeth, followed by rinsing the mouth with a solution of sodium bicarbonate. *The chemical antidote for acid poisoning is any mild alkali; as lime water, milk of magnesia, chalk, bicarbonate of soda, etc.*

Acidum Hydrochloricum, Hydrochloric Acid, HCl, U. S. P.—An aqueous solution containing not less than 35 per cent nor more than 37 per cent of HCl. Preserve it in glass-stoppered bottles. It should be noted that about 64 per cent of the liquid is water and only 36 per cent (by weight) is hydrochloric acid (gas). Absolute HCl is a gas and this preparation is a solution of HCl gas in water.

PREPARATION: It is made by acting on sodium chloride (common salt) with sulfuric acid. (1) $2NaCl+H_2SO_4=HCl+NaCl+NaHSO_4$; (2) $NaCl+NaHSO_4=HCl+Na_2SO_4$.

Properties: It is a colorless, fuming liquid having a pungent odor and an intensely acid taste. The fumes and odor disappear on adding the acid to twice its volume of water. It is strongly acid to litmus. Salts of hydrochloric acid are known as chlorides (sodium chloride). An aqueous solution containing not less than 9.5 Gm. nor more than 10.5 Gm. of HCl in each 100 cc is known as diluted hydrochloric acid.

Action and Uses: Hydrochloric acid is a normal constituent of the gastric juice and sometimes is administered to make up any deficiency of this substance in the gastric juice. Its principal use is in the manufacture of chlorides (salts), many of which are used in medicines. It is used with nitric acid in making nitrohydrochloric acid.

Average dose: 1 cc or 15 minims of the 10-per cent diluted acid. It should be diluted further with 1 fluidounce of water and taken through a glass tube, to avoid injury to the teeth.

Acidum Sulfuricum, Sulfuric Acid, H_2SO_4, U. S. P.—A liquid containing not less than 94 per cent nor more than 98 per cent of H_2SO_4. Preserve it in glass-stoppered bottles.

Properties: A colorless, odorless liquid, of oily consistence, very caustic and corrosive; strongly acid to litmus even when highly diluted. Specific gravity about 1.84 at 25° C. Miscible with water or alcohol with the evolution of much heat; *the acid must be added with great caution to the diluent. In mixing water and sulfuric acid the acid always should be added slowly with stirring to the water, and not the water to the acid.* When mixed in a glass vessel the acid should be added slowly to avoid a sudden increase of temperature with possibility of breaking the glass vessel. Because of its great affinity for water it is used as a desiccating (drying) agent. Being one of the strongest acids known, it is capable of decomposing salts of other acids, forming salts of sulfuric acid, and setting free the other acids. This principle is demonstrated in the making of hydrochloric and nitric acids.

Preparation: There are several methods now employed in the manufacture of sulfuric acid, the principles involved being practically the same. Sulfur is burned with the oxygen of the air forming sulfur dioxide; the sulfur dioxide is oxidized by the action of either an oxidizing agent (nitric acid) or a catalytic agent (platinum sponge) to sulfur trioxide. The sulfur trioxide then is brought in contact with steam in a leaden chamber (sulfuric acid does not act on lead), forming sulfuric acid. The simplest expression of the reactions involved is as follows:

$$(1)\quad S+O_2 = SO_2.$$
$$(2)\quad 3SO_2+2HNO_3 = 3SO_3+H_2O+N_2O_2.$$
$$(3)\quad SO_3+H_2O = H_2SO_4.$$

Diluted sulfuric acid is an aqueous solution containing not less than 9.5 Gm. nor more than 10.5 Gm. of H_2SO_4 in each 100 cc.

Action and Uses: Sulfuric acid rarely is given internally. Its principal use is in manufacturing other preparations. Not only is it used in the preparation of salts (sulfates) of sulfuric acid, but also in the manufacture of other acids from their salts.

Average dose of the diluted acid is 1 cc or 15 minims.

Acidum Nitricum, Nitric Acid (Aqua Fortis), HNO_3, U. S. P.—An aqueous solution containing not less than 67 per cent nor more than 70 per cent of HNO_3. Preserve it in glass-stoppered bottles protected from light, and in a cool place.

Properties: Nitric acid is a fuming liquid, very caustic and corrosive, and has a peculiar, somewhat suffocating odor. It should be handled with extreme care.

PREPARATION: Made by the action of sulfuric acid on sodium nitrate. $NaNO_3+H_2SO_4=NaHSO_4+HNO_3$.

ACTION AND USES: Nitric acid rarely is given internally. It is used in the manufacture of salts of nitric acid (nitrates) and in the manufacture of explosives (trinitro-phenol, glyceryl trinitrate, trinitro-toluol, etc.). It is an extensively used oxidizing agent, breaking down in the presence of oxidizable substances, as follows: $2HNO_3=H_2O+N_2O_2+3O$. Applied to tissues it acts as an energetic caustic and is used for cauterization and to remove warts. It is used with hydrochloric acid in the preparation of nitrohydrochloric acid. When applied to the skin it produces a yellow stain due to the formation of xanthoproteic acid.

The alkali elements and their compounds.

The alkali metals are *potassium, sodium, lithium, and the radical ammonium.* Chemically they are strongly electropositive, being directly opposite to the halogens. They are monovalent, soft, waxlike in consistence, having a low melting point, readily oxidize in the air and decompose water forming strong hydroxides (alkalies). These strong alkalies are very caustic and poisonous. Nearly all the salts of these alkalies (formed by their union with acids) are soluble in water. Potassium, sodium, and lithium as such have no special medicinal action of value. The medicinal properties of their chemical compounds are exerted by the acid radicals with which they are combined; therefore the medicinal properties of the alkali salts vary greatly. *The chemical antidote for the strong alkalies is any weak acid, as citric acid, vinegar, diluted acetic acid, etc.* Neutralization of the acid should be followed by giving large doses of cottonseed oil. When acids and alkalies are brought together in solution they neutralize each other forming new compounds (salts). In this way they act as antidotes for each other.

Potassii Hydroxidum, Potassium Hydroxide (Caustic Potash), KOH, U. S. P.—It contains not less than 85 per cent of KOH. Preserve it in well-closed containers. If bottles are used they must be made of hard glass, and cork stoppers should be paraffined.

PROPERTIES: Potassium hydroxide occurs in dry, white, or nearly white flakes, fused masses, or sticks; is hard, brittle and odorless. *Great caution is necessary in handling it, as it rapidly destroys organic tissue.* When exposed to the air it rapidly absorbs carbon dioxide and moisture and deliquesces. It is very soluble in water, alcohol and glycerin. (All the salts of potassium are soluble in water except potassium bitartrate). It is strongly alkaline to red litmus, turning it blue even in a very dilute solution.

PREPARATION: It is made by electrolysis (passing an electric current through potassium chloride).

ACTION AND USES: Pure potassium hydroxide is not given internally. *If a large quantity should be swallowed accidentally,* give vinegar or lemon juice as the antidote. Potassium hydroxide is used in making soap (soft soap). Lye may be composed of potassium hydroxide, although it usually contains sodium hydroxide, a cheaper substance. It sometimes is used as a caustic, but its principal use in medicine is in the manufacture of potassium salts.

Potassii Acetas, Potassium Acetate, CH_3COOK, U. S. P.—It contains when dried to constant weight at 150° C. not less than 99 per cent of CH_3COOK. Preserve it in airtight containers.

PROPERTIES: It is very deliquescent on exposure to the air, and is very soluble in both water and alcohol. An aqueous solution is alkaline to litmus.

PREPARATION: It is made by the action of acetic acid on potassium bicarbonate. $KHCO_3+CH_3COOH=CH_3COOK+CO_2+H_2O$.

ACTION AND USES: Used as a diuretic, diaphoretic, and to render the urine alkaline. In large doses it acts as a laxative. It is decomposed in the system, forming carbonates.

Average dose: 1 Gm. or 15 grains.

Potassii Bicarbonas, Potassium Bicarbonate, $KHCO_3$, U. S. P.—It contains, when dried to constant weight in a desiccator over sulfuric acid, not less than 99 per cent of $KHCO_3$. Preserve it in well closed containers.

PROPERTIES: It is very soluble in water, but almost insoluble in alcohol. When a solution of potassium bicarbonate is heated it is converted into potassium carbonate. An aqueous solution is slightly alkaline to litmus.

PREPARATION: It is made by passing carbon dioxide through a solution of potassium carbonate until it is fully saturated. $K_2CO_3+CO_2+H_2O=2KHCO_3$.

ACTION AND USES: Its action when given internally is very much like that of potassium acetate. It renders the blood and urine alkaline. In manufacturing pharmacy it is used in the preparation of many of the other potassium salts.

Average dose: 1 Gm. or 15 grains.

Potassii Bitartras, Potassium Bitartrate (Cream of Tartar), KOOC.CHOH.CHOH.COOH, U. S. P.—It contains, when dried to constant weight at 100° C., no less than 99.5 per cent of KOOC.CHOH.CHOH.COOH. Preserve it in well-closed containers.

PROPERTIES: Occurs as a colorless or slightly opaque, gritty powder, odorless, and having a pleasant acidulous taste. It is very slightly soluble in water (the only sparingly soluble potassium salt in common use), and insoluble in alcohol. A saturated solution is acid to litmus.

PREPARATION: It is made by purifying tartar, a substance deposited in wine casks during fermentation of grape juice in making grape wines.

ACTION AND USES: Occasionally given as a hydragogue cathartic. It is one of the constituents of baking powders. In baking powder it acts slowly on bicarbonate of sodium, liberating carbon dioxide, which becómes entangled in the dough and causes it to rise. It sometimes is used as a diuretic and laxative. Tartrates are not oxidized in the system like citrates and acetates and do not act as alkalizers.

Average dose: 2 Gm. or 30 grains.

Potassii Chloras, Potassium Chlorate, $KClO_3$, U. S. P.—It contains not less than 99 per cent of $KClO_3$. Preserve it in well-closed containers. Great caution should be observed in handling it, as dangerous explosions are liable to occur when it is heated or subjected to concussion or trituration with organic substances (cork, tannin, dust, sugar, etc.) or with sulfur, sulfides, hyposulfites, or other easily oxidizable substances.

PROPERTIES: It occurs as colorless crystals or a white granular powder, odorless, and having a peculiar cooling taste. It is soluble in 16.5 parts of water, soluble in glycerin, and insoluble in alcohol. It is capable of yielding oxygen when heated.

PREPARATION: It is made by boiling together a solution of potassium chloride and calcium hypochlorite.

ACTION AND USES: Applied locally in aqueous solution it acts as an antiseptic and stimulant to mucous membranes. It is decomposed easily by septic matter, yielding nascent oxygen, to which it owes its antiseptic properties. It is used in the following inflammatory conditions of mucous membranes: Catarrhal inflammations of the mouth and fauces, ulcerative and mercurial

stomatitis, nursing sore mouth, and tonsillitis. When given internally in large doses it is likely to cause destruction of the red blood cells.

Average dose: 0.25 Gm. or 4 grains (rarely used internally).

Potassii et Sodii Tartras, Potassium and Sodium Tartrate (Rochelle Salt), U. S. P.—It contains, when rendered anhydrous by drying at 150° C., not less than 99 per cent of KOOC.CHOH.CHOH.COONa. It contains not less than 21 per cent and not more than 26 per cent of water. Preserve it in well-closed containers.

Properties: Occurs as colorless, transparent crystals or a white granular powder, odorless, and having a saline taste. Very soluble in water and almost insoluble in alcohol and slightly efflorescent in dry air. Its aqueous solution is slightly alkaline to litmus.

Preparation: Made by adding potassium bitartrate to a solution of sodium carbonate. $2KHC_4H_4O_6+Na_2CO_3=2KNaC_4H_4O_6+CO_2+H_2O$.

Action and Uses: Rochelle salt is an extensively used purgative in the form of Seidlitz powder, U. S. P. A Seidlitz powder consists of two powders, one wrapped in white paper, and the other wrapped in blue paper. The contents of the blue paper are: Rochelle salt, 115 grains, and sodium bicarbonate, 38 grains. The white paper contains 33 grains of tartaric acid. When administered the contents of the two powders are dissolved separately, each in half a glass of water, and then poured together and taken while effervescing. The effervescence is caused by the action of the tartaric acid on the bicarbonate of sodium. In this reaction sodium bitartrate is formed.

Average dose: 10 Gm. to 2½ drams.

Potassii Iodidum, Potassium Iodide, KI, U. S. P.—It contains, when dried to constant weight at 100° C., not less than 99 per cent of KI. Preserve it in well closed containers.

Properties: It is very soluble in water and glycerin; slightly soluble in alcohol. Slightly deliquescent in moist air. Its aqueous solution is slightly alkaline to litmus.

Preparation: It is made by the action of iodine on an aqueous solution of potassium hydroxide. (1.) $6KOH+3I_2=5KI+KIO_3+3H_2O$. (2.) $KIO_3+3C=KI+3CO$.

Action and Uses: A valuable and much used alterative. It is used in the treatment of syphilis, rheumatism, and arteriosclerosis. It also is used for chronic lead, mercury, and arsenic poisoning, forming with these metals double soluble salts which are eliminated easily.

Average dose: 0.3 Gm. or 5 grains. Give small doses for chronic lead poisoning and large doses for syphilis.

Potassii Permanganas, Potassium Permanganate, $KMnO_4$, U. S. P.—It contains, when dried to constant weight in a desiccator over sulfuric acid, not less than 99 per cent of $KMnO_4$. Preserve it in glass-stoppered bottles. *Potassium permanganate when in solution or in the dry condition must not be brought into contact with organic or other readily oxidizable substances, as dangerous explosions are liable to occur.*

Properties: It occurs as slender prisms, of a dark purple color, odorless and having a disagreeable astringent taste. It is stable in the air. It is soluble in 14.2 parts of water. *An alcoholic solution cannot be made because it is decomposed by alcohol.* It is a powerful oxidizing agent, two molecules in acid solution yielding five atoms of oxygen. When it comes in contact with organic matter it is decomposed with the liberation of oxygen. This property makes it a valuable antiseptic and disinfectant.

PREPARATION: It may be made by fusing together a mixture of potassium hydroxide, manganese dioxide, and potassium chlorate, forming potassium manganate. When the potassium manganate is boiled with water potassium permanganate is formed.

(1) $3MnO_2+6KOH+KClO_3=3K_2MnO_4+KCl+3H_2O$.
(2) $3K_2MnO_4+3H_2O=2KMnO_4+MnO_2+4KOH+H_2O$.

ACTION AND USES: It is used as an antiseptic astringent irrigating fluid, especially for the urethra and bladder, in strengths of from 1–4,000 to 1–10,000. It seldom is used externally, largely on account of the objectionable stain which it leaves. A 5 per cent solution is used in the treatment of poisoning by venomous snakes by injection into the wound. It also is used in the treatment of morphine poisoning. It has been used with formaldehyde solution to volatilize formaldehyde gas in disinfection of rooms, but is has been displaced for this purpose by barium dioxide, a cheaper substance.

Average dose: 0.06 Gm. or 1 grain.

Sodii Hydroxidum, Sodium Hydroxide (Caustic Soda, Sodium Hydrate), NaOH, U. S. P.—It contains not less than 95 per cent of NaOH. Preserve it in well-closed containers. If bottles are used as containers they must be made of hard glass, and cork stoppers should be paraffined.

PROPERTIES: It occurs in dry, white or nearly white fused masses or sticks, hard and brittle, showing a crystalline fracture. Exposed to the air, it rapidly deliquesces, absorbs carbon dioxide, and becomes covered with a coating of sodium carbonate. *Great caution is necessary in using it, as it rapidly destroys organic tissue.* It is very soluble in water and alcohol. It closely resembles potassium hydroxide in its properties, being a very strong alkali.

PREPARATION: It is made by electrolysis of sodium chloride; also by the action of slaked lime on a solution of sodium carbonate. ($Na_2CO_3+Ca(OH)_2=2NaOH+CaCO_3$.)

ACTION AND USES: It is used in the preparation of compound cresol solution, solution of sodium hydroxide, and magma magnesia. It seldom is used internally, because it is too caustic. As a caustic it may be used like potassium hydroxide. *The antidote is vinegar, diluted acetic acid, citric acid, lemon juice, etc.* Sodium hydroxide is used extensively in a crude, impure form, for household cleaning under the name of lye.

Sodii Bicarbonas, Sodium Bicarbonate (Bicarbonate of Soda, Baking Soda), $NaHCO_3$, U. S. P.—It contains, when dried to constant weight in a desiccator over sulfuric acid, not less than 99 per cent of $NaHCO_3$. Preserve it in well-closed containers in a cool place.

PROPERTIES: It is a white, crystalline powder, odorless and having a cooling, mildly alkaline taste. It is stable in dry air, but slowly decomposes in moist air. When its aqueous solution is heated, even mildly, it loses carbon dioxide and is converted into sodium carbonate as follows: $2NaHCO_3=Na_2CO_3+H_2O+CO_2$. It is fairly soluble in water, and insoluble in alcohol. Its aqueous solution is alkaline to litmus, and the alkalinity increases as the solution stands, is agitated or heated. When treated with acids it effervesces (the same thing occurs when any carbonate is treated with an acid).

PREPARATION: It is made by the Solvay process (ammonia soda process). A concentrated solution of sodium chloride is mixed with ammonia water; carbon dioxide under pressure is forced into this mixture, resulting in the formation of sodium bicarbonate and ammonium chloride. Sodium bicarbonate is precipitated (being less soluble) and the ammonium chloride remains in solution. The reaction may be expressed: $NaCl+NH_3+CO_2+H_2O=NaHCO_3+NH_4Cl$. This

process also may be used in making sodium carbonate. After making the bicarbonate this may be heated, driving off carbon dioxide and water, leaving behind sodium carbonate.

ACTION AND USES: A valuable and popular antacid. It is given frequently for hyperacidity of the stomach (heartburn), but it must be remembered that while it neutralizes the acid contained in the stomach it also causes increased secretion of more acid, and may defeat the purpose for which it is given if administered over a long period. When used for heartburn it usually is combined with ammonium carbonate and oil of peppermint and given in tablet form (soda-mint tablets). It is used externally in saturated aqueous solution for the treatment of burns and poisoning by poison ivy. It may be used in the preparation of other compounds of sodium. It is the principal ingredient in baking powder. In making bread this substance, when acted upon by either alum or cream of tartar, liberates carbon dioxide, which becomes entangled in the dough and causes it to rise. The term "soda" very often is applied to this compound, but "soda" is an indefinite term and might mean sodium carbonate or even caustic soda. For the preparation of sterile solution of sodium bicarbonate for intravenous use *see* U. S. P. page 468. A solution for intravenous use should be colorless with phenolphthalein.

Average dose: 1 Gm. or 15 grains.

Sodii Biphosphas, Sodium Biphosphate (Sodium Dihydrogen Phosphate, Sodium Acid Phosphate), NaH_2PO_4, U. S. P.—Sodium biphosphate, when dried to constant weight at 100° C., contains not less than 98 per cent of NaH_2PO_4. It contains not less than 10 per cent and not more than 15 per cent of water. Preserve it in air-tight containers.

DESCRIPTION: Colorless crystals or a white, crystalline powder. It is odorless and is slightly deliquescent. It is freely soluble in water but is practically insoluble in alcohol. An aqueous solution of the salt is acid to litmus paper and effervesces with sodium carbonate.

ACTION AND USES: It is given to increase the acidity of the urine. It is given in conjunction with methenamine, not at the same time but between the methenamine doses, in order to render the urine acid when the methenamine is excreted by the kidneys. The acid urine decomposes the methenamine setting free formaldehyde which acts as an antiseptic in the urinary tract. If sodium biphosphate and methenamine are given at the same time decomposition between the two will take place in the stomach which is not desired. If sodium biphosphate is not available use sodium phosphate and to each gram of sodium phosphate in solution add 1 cc of diluted hydrochloric acid or 4 cc of diluted phosphoric acid.

Average dose: 0.6 Gm. or 10 grains.

Sodii Boras, Sodium Borate (Borax, Sodium Tetraborate, Sodium Pyroborate), U. S. P.—It contains not less than 52.32 per cent nor more than 54.92 per cent of anhydrous sodium borate (sodium biborate or tetraborate), corresponding to not less than 99 per cent of the crystallized salt ($Na_2B_4O_7+10H_2O$). Preserve it in well-closed containers.

PROPERTIES: It occurs as colorless, transparent prisms, or as a white powder, odorless, and having a sweetish alkaline taste. It is slightly efflorescent in warm, dry air. It is fairly soluble in water, very soluble in glycerin, and insoluble in alcohol. Its aqueous solution is alkaline to litmus. It has the properties of an alkali but is milder than sodium carbonate. When mixed with glycerin it decomposes alkali bicarbonates with effervescence (this accounts for the effervescence in the preparation of Dobell's solution). An aqueous solution shows an alkaline reaction toward litmus, but when dissolved in glycerin it

gives an acid reaction, and when the glycerin solution is largely diluted with water the reaction is changed back to alkaline.

PREPARATION: Sodium borate is found native (as sodium borate) as a crystalline deposit in the blue mud at the bottom of Clear Lake and near Death Valley in California, and in lakes in other parts of the world. It can be made by treating crude boric acid with sodium carbonate.

ACTION AND USES: Sodium borate possesses mild antiseptic and cleansing properties, and because of them it is used very often in alkaline mouth washes and gargles. It is one of the ingredients in compound solution of sodium borate, N. F. (Dobell's solution). It rarely is used internally. As a household cleaning agent (borax) it is used extensively where a mild alkali is desired in the cleaning of delicate fabrics. It also is used as a food preservative. A 1 per cent solution in distilled water is used as an eye lotion in conjunctivitis.

Sodii Bromidum, Sodium Bromide. NaBr, U. S. P.—It contains, when dried to constant weight at 100° C., not less than 99 per cent of pure NaBr. Preserve it in well-closed containers.

PROPERTIES: It occurs as colorless, or white, cubical crystals, or as a white powder, odorless, and having a saline taste. It is very soluble in water and fairly soluble in alcohol. Its aqueous solution is neutral or faintly alkaline to litmus. It absorbs moisture from the air without deliquescing.

PREPARATION: It can be made by methods like those employed in making potassium bromide, using NaOH instead of KOH.

ACTION AND USES: It is used as a cerebral depressant and nerve sedative. Its action is much like that of potassium bromide, but less irritating to the stomach and less depressing. It is useful for quieting nervous excitability in neurasthenia and hysteria. It is given as an adjunct to hypnotics such as chloral. When given for a long time it disturbs the digestion and produces irritation of the skin.

Average dose: 1 Gm. or 15 grains.

Sodii Carbonas Monohydratus, Monohydrated Sodium Carbonate, $Na_2CO_3+H_2O$, U. S. P.—It contains, when rendered anhydrous by gentle ignition, not less than 99.5 per cent Na_2CO_3, and not less than 10 per cent and not more than 15 per cent of water. Preserve it in well-closed containers.

PROPERTIES: It is a white, crystalline, granular powder, odorless and having a strong alkaline taste and reaction. When exposed to the air, under ordinary conditions, it absorbs only a slight percentage of moisture; exposed to warm, dry air at or above 50° C., the salt effloresces, and at 100° C. it becomes anhydrous. It is very soluble in water and glycerin, and is insoluble in alcohol. An aqueous solution is strongly alkaline to litmus paper.

PREPARATION: There are three methods by which sodium carbonate may be made: LeBlanc's process, the Cryolite process, and the Solvay process. The Solvay process has been explained under sodium bicarbonate. (The chemical reactions involved in the LeBlanc and the Cryolite processes are too complicated to treat in this book. The student is referred to standard textbooks on pharmacy for further information.)

ACTION AND USES: Because of its strong alkaline reaction and irritating effect on the stomach, sodium carbonate seldom is given internally; sodium bicarbonate is preferred when the internal antacid effect of soda is desired. Added to water in which instruments are being boiled (1 teaspoonful to a gallon of water), it prevents their rusting (sodium bicarbonate and borax will do the same thing). It is used in washing clothes when a strong alkali is desired. ("Washing soda" is a term applied to sodium carbonate containing 10 molecules of water of crystallization.)

Average dose: 0.25 Gm. or 4 grains.

Sodii Chloridum, Sodium Chloride (Common Salt), NaCl, U. S. P.—It contains, when dried to constant weight at 110° C., not less than 99.5 per cent of pure NaCl. Preserve it in well-closed containers.

PROPERTIES: It occurs as colorless, cubical crystals, or white crystalline powder, odorless, and having a saline taste. Its aqueous solution is neutral to litmus. It is very soluble in water, fairly soluble in glycerin, and slightly soluble in alcohol. Its solubility in water is not increased by heating the water.

PREPARATION: It occurs in the native state as rock salt in large deposits throughout the world. Sea water contains about 3 per cent of this salt mixed with other salts. The waters of Great Salt Lake in Utah contain about 20 per cent of NaCl. It must be purified and freed from other salts before it is fit for medicinal or domestic use.

ACTION AND USES: A tablespoonful to a glassful of tepid water is used as an emetic. As a condiment it is almost a daily necessity in the human economy. It is found in all fluids and tissues of the body. A weak aqueous solution is used as a gargle and nasal douche. It is used in the preparation of physiological solution of sodium chloride, U. S. P. This solution contains in every 1,000 cc, 8.5 Gm. of sodium chloride, and is commonly known as normal salt solution. While usually used in this strength solutions up to 2 per cent may be given if necessary. Nearly all drugs that are injected into the system, either hypodermically or intravenously, are dissolved in physiological salt solution, or one slightly weaker, in order that they will be isotonic (same salt density as the blood) when injected into the circulation.

Average dose: 15 Gm. or 240 grains dissolved in warm water as an emetic.

Liquor Sodii Chloridi Physiologicus, Physiological Solution of Sodium Chloride (Physiological Salt Solution, Normal Salt Solution), U. S. P.—

Sodium chloride	8.5 Gm.
Distilled water, a sufficient quantity	
To make	1000.0 cc.

Dissolve the sodium chloride in sufficient freshly distilled water, neutral to litmus paper, to measure 1,000 cc, and filter, returning the filtrate until free from foreign particles. Transfer the solution to a sterile flask of insoluble glass having a capacity of about 1,000 cc, and stopper with a plug of purified, nonabsorbent cotton, wrapped in gauze. Fasten stout, nonabsorbent paper or tinfoil over the top of the cotton and the lip of the container, and sterilize in an autoclave under steam pressure, maintaining a temperature of not less than 115° C. for 30 minutes. This solution must be protected from contamination and should be used intravenously within 24 hours after its preparation and sterilization.

Sodii Citras, Sodium Citrate, U. S. P.—It contains not less than 99 per cent of $C_3H_4.(OH).(COONa)_3$ and not less than 10 per cent nor more than 13 per cent of water. Preserve it in well-closed containers.

PROPERTIES: Occurs as a white granular powder, odorless, and having a cooling saline taste. It is very soluble in water, and is insoluble in alcohol. An aqueous solution is slightly alkaline to litmus. It has the property of holding in solution certain insoluble substances, a property possessed by other alkaline citrates.

PREPARATION: It is made by the action of citric acid on sodium carbonate, $2C_3H_4(OH)(COOH)_3+3Na_2CO_3=2C_3H(OH)(COONa)_3+3CO_2+3H_2O$.

ACTION AND USES: An aqueous solution has the property of preventing coagulation of the blood and delaying the curdling of milk. A solution containing 2 grains of sodium citrate and 20 grains of sodium chloride to 1 fluidounce of water (Wright's solution) is used for the irrigation of wounds and as a local application for furunculosis. For modifying cow's milk in infant feeding to prevent the formation of large curds, 1 grain of sodium citrate to 1 fluidounce of milk may be used. Its action in preventing coagulation of the blood and delaying milk curdling is supposed to be due to the formation of calcium citrate, which does not ionize and is therefore inactive. It is used in Pharmacy as a buffer agent.

Average dose: 1 Gm. or 15 grains.

Sodii Iodidum, Sodium Iodide, U. S. P.—It contains not less than 99 per cent of NaI.

PROPERTIES: Colorless, odorless crystals, or a white, granular powder. In moist air it cakes and then deliquesces, and frequently undergoes decomposition, developing a brown tint. It is very soluble in water, alcohol, and glycerin. It should be preserved in airtight containers.

ACTION AND USES: It has the same action as potassium iodide but is less irritating to the stomach. The "iodized table salt" sold in the United States contains 0.1 Gm. of sodium iodide in each 1,000 Gm. of sodium chloride.

Average dose: 0.3 Gm. or 5 grains.

Sodii Perboras, Sodium Perborate, U. S. P.—It contains not less than 9 per cent of available oxygen, corresponding to about 86.5 per cent of $NaBO_3.4H_2O$. Preserve it in well-closed containers.

PROPERTIES: It occurs as white, crystalline granules or as a white powder. It is odorless and has a saline taste. It is stable in cool dry air, but is decomposed with the evolution of oxygen in warm or in moist air. One gram is soluble in 40 cc of water. In aqueous solution sodium perborate is decomposed into sodium metaborate and hydrogen peroxide, the solution gradually evolving oxygen. Oxygen is evolved more rapidly if the solution is warm. A saturated aqueous solution is alkaline to litmus paper.

ACTION AND USES: It is used as a cleansing mouth antiseptic. It is used in tooth pastes, tooth powders, and mouth washes. Solutions of sodium perborate should be prepared fresh as they easily decompose on standing.

Average dose: 0.06 Gm., or 1 grain.

Sodii Phosphas, Sodium Phosphate, $Na_2HPO_4+7H_2O$, U. S. P.—It contains, when dried to constant weight at 110° C., not less than 98 per cent of Na_2HPO_4. It contains not less than 43 per cent and not more than 50 per cent of water. Preserve it in well-closed containers in a cool place.

PROPERTIES: Occurs as a colorless or white, granular salt, efflorescent in warm, dry air. It is very soluble in water and slightly soluble in alcohol. An aqueous solution is alkaline to litmus. If sodium phosphate is stored in a warm storeroom, much of the water of crystallization separates and the sodium phosphate settles in the bottom of the bottle, forming a hard mass that cannot be removed without breaking the bottle. This hard mass, having lost most of its water of crystallization, is much stronger than the granular salt.

PREPARATION: Sodium phosphate is made from the inorganic part of animal bones. Bones contain a large amount of calcium phosphate ($Ca_3(PO_4)_2$), which by a series of reactions is converted into sodium phosphate. Sodium phosphate, if not properly prepared, may contain arsenic as an impurity through the use of impure sulfuric acid in its manufacture.

ACTION AND USES: It is used as a saline cathartic, acting much like magnesium sulfate. It is administered dissolved in warm water and given before breakfast. It is considered an excellent remedy in catarrhal jaundice and chronic gastric catarrh.

Average dose: 4 Gm. or 60 grains.

Sodii Salicylas, Sodium Salicylate, $NaC_7H_5O_3$, U. S. P.—It contains, when dried to constant weight at 100° C., not less than 99.5 per cent of pure $C_6H_4.OH.COONa$. Preserve it in well-closed containers, protected from heat and light.

PROPERTIES: Occurs as a white powder, or scales, or an amorphous powder, colorless or with a faint pink tinge, odorless, and having a sweet saline taste. Soluble in 0.9 part of water, 9.2 parts of alcohol, and in 4 parts of glycerin. An aqueous solution is neutral or faintly acid to litmus.

PREPARATION: It is prepared by mixing pure salicylic acid with sufficient distilled water to form a paste and then with pure, crystallized sodium carbonate (uneffloresced), the reaction being: $2C_6H_4(OH)COOH+Na_2CO_3=2C_6H_4(OH)COONa+H_2O+CO_2$.

ACTION AND USES: It is used as an antirheumatic, analgesic, and antipyretic. It is a valuable remedy in the treatment of rheumatism, tonsillitis, and influenza. It should be given with sodium bicarbonate to prevent precipitation of salicylic acid by the hydrochloric acid in the stomach.

Average dose: 1 Gm. or 15 grains.

Sodii Thiosulfas, Sodium Thiosulfate (Hypo, Sodium Hyposulfite) $Na_2S_2O_3+5H_2O$, U. S. P.—It contains, when rendered anhydrous by drying to constant weight at 100° C., not less than 99 per cent of $Na_2S_2O_3$. It contains not less than 32 per cent and not more than 37 per cent of water. Preserve it in well-closed containers.

PROPERTIES: Occurs as large, colorless crystals or a coarse crystalline powder. It is permanent in the air below 33° C., but effloresces in dry air above that temperature; deliquescent in moist air. Soluble in 0.5 part of water and insoluble in alcohol. When an aqueous solution is boiled the salt is decomposed rapidly. When brought in contact with a solution of iodine it immediately decolorizes the iodine, forming new compounds. It is capable of dissolving the halogen compounds of silver, as: $AgBr+Na_2S_2O_3=NaAgS_2O_3+NaBr$. An aqueous solution is faintly alkaline to litmus paper.

PREPARATION: It can be made by treating calcium thiosulfate with sodium carbonate, $CaS_2O_3+Na_2CO_3=CaCO_3+Na_2S_2O_3$.

ACTION AND USES: An aqueous solution of 1 in 10 may be used for various parasitic diseases of the skin. In the absence of starch it may be used for iodine poisoning. *An aqueous solution is the best agent for removing iodine stains from linen.* It is used extensively in photography as a fixing bath.

Average dose: 1 Gm. or 15 grains.

Sodii Sulfas, Sodium Sulfate (Glauber's Salt), U. S. P.—When rendered anhydrous by drying at 120° C. it contains not less than 99 per cent of Na_2SO_4. It contains not less than 51 per cent and not more than 57 per cent of water. Preserve it in well-closed containers.

DESCRIPTION: Large, colorless, odorless, transparent crystals or a granular powder. The salt effloresces rapidly in the air. One Gm. is soluble in 1.5 cc of water. It is insoluble in alcohol but is soluble in glycerin. It liquefies in its water of hydration at about 33° C., and at 100° C. it loses all of its water of hydration. An aqueous solution of the salt is neutral to litmus paper.

ACTION AND USES: It is used as a saline cathartic. It is sometimes given with other salts. *See* Artificial Carlsbad Salt, N. F.

Average dose: 15 Gm.

Liquor Sodii Hypochloritis, Solution of Sodium Hypochlorite, U. S. P.— CAUTION: *This solution is not suitable for application to wounds.*

DESCRIPTION: A clear, pale, greenish-yellow liquid, having a slight odor of chlorine. The solution first colors red litmus paper blue and then bleaches it. The addition of diluted hydrochloric acid to the solution causes evolution of chlorine. Preserve it in well-stoppered bottles in a cool place protected from light.

ACTION AND USES: This solution is used in preparing the Diluted Solution of Sodium Hypochlorite, U. S. P.

Liquor Sodii Hypochloritis Dilutus, Diluted Solution of Sodium Hypochlorite, U. S. P.—An aqueous solution of chlorine compounds of sodium containing in each 100 cc not less than 0.45 Gm. and not more than 0.50 Gm. of NaOCl, equivalent to not less than 0.43 Gm. and not more than 0.48 Gm. of available chlorine when prepared as directed in the U. S. P.

DESCRIPTION: A colorless or faintly yellow liquid having a slight odor suggesting chlorine. Preserve it in well-stoppered bottles in a cool place protected from light.

ACTION AND USES: This is Modified Dakin's Solution. It is used for continuous irrigation of infected wounds. This solution can also be prepared by passing chlorine gas through a solution of sodium carbonate.

Aqua Ammoniæ Fortior, Stronger Ammonia Water, U. S. P.—An aqueous solution of ammonia (NH_3) containing not less than 27 per cent nor more than 29 per cent by weight of NH_3. This solution deteriorates rapidly in open containers. Preserve it in a cool place in glass-stoppered or rubber-stoppered bottles made of hard glass, free from lead. *Great caution should be used in handling this liquid because of its caustic and irritating properties and it must never be tasted or smelled unless very greatly diluted.*

PROPERTIES: It has an excessively pungent, characteristic odor and a very caustic and alkaline taste. In its chemical properties it closely resembles the solutions of potassium or sodium hydroxide, being a strong, caustic alkali. If kept in a warm place, ammonia (NH_3) is liberated and held in the upper part of the bottle; therefore great care should be exercised in opening the bottle to see if the stopper has been secure and has not allowed the gas to escape. *There is danger of the sudden escape of a large amount of gas, which might cause injury to the eyes or mucous membranes of the nose and throat by inhalation.*

PREPARATION: Ammonia is a by-product in the manufacture of illuminating gas. When coal is subjected to destructive distillation ammonia is one of the products formed. The gases formed are passed through an acid solution (sulfuric or hydrochloric) and an ammonium salt is formed (ammonium sulfate or chloride, according to the acid used). This salt then is heated with lime, ammonia (NH_3) is set free, and after passing it through quicklime it is passed into water until a saturated solution is formed.

ACTION AND USES: *Stronger ammonia water is never given internally.* It is used in making the weaker solution of ammonia, known as ammonia water. Ammonia water is an aqueous solution of ammonia (NH_3) containing not less than 9.0 grams nor more than 10.0 grams of NH_3 in each 100 cc. This solution is used in making aromatic spirit of ammonia and ammonia liniment. *The antidote for ammonia water is weak acids the same as for other alkaline hydroxides.* Inhalations of ammonia gas stimulate the heart and respiratory cen-

ter. Œdema of the glottis, resulting in obstructed breathing, might result in giving inhalations of concentrated ammonia gas; therefore care should be exercised in giving inhalations to an unconscious patient.

Ammonii Chloridum, Ammonium Chloride (Sal Ammoniac, Ammonium Muriate), NH_4Cl, U. S. P.—It contains, when dried for 24 hours over sulfuric acid, not less than 99.5 per cent of NH_4Cl.

PROPERTIES: It is soluble in 2.6 parts of water, 100 parts of alcohol, and 8 parts of glycerin. On heating it does not melt, but passes directly to the gaseous state. It occurs as colorless crystals or a white, crystalline powder, having a cool saline taste. It is somewhat hygroscopic.

PREPARATION: It is chiefly made from *gas liquor*, the ammoniacal liquid obtained from gas works during the destructive distillation of coal in the manufacture of illuminating gas, and neutralized with hydrochloric acid: $NH_3 + HCl = NH_4Cl$.

ACTION AND USES: It is a valuable stimulant expectorant and often is used in cough mixtures (Brown mixture with ammonium chloride). Large doses lower the alkali reserve of the blood and increase the acidity of the urine. Large doses irritate the stomach and must be given in capsules coated with stearic acid or other enteric coating.

Average dose: 0.3 Gm. or 5 grains.

Ammonii Carbonas, Ammonium Carbonate, U. S. P.—It consists of a mixture of acid ammonium carbonate (NH_4HCO_3) and ammonium carbamate ($NH_4NH_2CO_2$) in varying proportions, and yields not less than 30 per cent nor more than 32 per cent of NH_3. Preserve it in airtight containers in a cool place protected from light. For medicinal purposes use only the translucent portions.

PROPERTIES: It occurs in white, hard, translucent masses, having an ammoniacal odor. On exposure to the air the salt loses both ammonia and carbon dioxide, becoming opaque, and finally is converted into friable, porous lumps or a white powder. It is soluble in 4 parts of water and is decomposed by hot water with the elimination of carbon dioxide and ammonia. Alcohol dissolves the carbamate, but leaves the acid ammonium carbonate. An aqueous solution is alkaline to litmus.

PREPARATION: At present it is made principally by the sublimation of a mixture of ammonium sulfate and calcium carbonate, $2(NH_4)_2SO_4 + 2CaCO_3 = 2CaSO_4 + NH_4HCO_3.NH_4NH_2CO_2 + NH_3 + H_2O$.

ACTION AND USES: It is used in making aromatic spirit of ammonia and solution of ammonium acetate. It is a stimulant expectorant and heart stimulant, and is used in expectorant mixtures and smelling salts. It should never be given in powdered form because it is irritating. Mixed with an equal bulk of stronger ammonia water and scented with oil of lavender, it constitutes the common smelling salts.

Average dose: 0.3 Gm. or 5 grains.

Spiritus Ammoniæ Aromaticus, Aromatic Spirit of Ammonia, U. S. P.—It contains in each 100 cc, not less than 1.7 Gm. and not more than 2.1 Gm. of total NH_3; and ammonium carbonate, corresponding to not less than 3.5 Gm. and not more than 4.5 Gm. as $(NH_4)_2CO_3$. Preserve it in glass-stoppered bottles, in a cool place and protected from light.

DESCRIPTION: A nearly colorless liquid when freshly prepared, but gradually acquiring a yellow color on standing. It has the taste of ammonia, and an aromatic and pungent odor.

ACTION *and* USES: It is used as a reflex stimulant to prevent fainting, and to relieve nausea or sick headache caused by hyperacidity of the gastric juice.

It should be given well diluted with water. It contains from 62 to 68 per cent of alcohol.

Average dose: 2 cc or 30 minims.

The alkaline earth elements and their compounds.

The alkaline earth elements are *magnesium, calcium, strontium,* and *barium.* They are called alkaline earth elements because their oxides have marked alkaline (basic) properties, and the compounds of these elements are found abundantly in the earth. They are all divalent and are strongly electropositive. Their compounds are not nearly as soluble as the compounds of the alkali elements; in fact, many of their compounds are insoluble in water. The hydroxides, carbonates, and sulfates (except magnesium sulfate) are insoluble or only slightly soluble in water. Their alkaline properties are not as intense as in the case of the alkali elements (sodium, potassium, lithium), and their hydroxides are classed as mild alkalies (milk of magnesia and lime water).

Magnesium compounds.

Magnesii Carbonas, Magnesium Carbonate, U. S. P.—Basic hydrated magnesium carbonate, equivalent to not less than 39.2 per cent and not more than 41.5 per cent of MgO.

Properties: It occurs as light, white, friable masses, or a white, bulky powder, odorless, and having a slight earthy taste. It is practically insoluble in water and alcohol. It is stable in the air.

PREPARATION: It is made by mixing cold dilute solutions of magnesium sulfate and sodium carbonate: $5MgSO_4+5Na_2CO_3+H_2O=4MgCO_3.Mg(OH)_2+5Na_2SO_4+CO_2$.

ACTION AND USES: It is used in making solution of magnesium citrate and magnesia magma. It is given internally as an antacid and as an antidote for acid poisoning.

Average dose: 3 Gm. or 45 grains.

Magnesii Sulfas, Magnesium Sulfate (Epsom Salt) $MgSO_4.7H_2O$, U. S. P.—It contains, when rendered anhydrous by ignition, not less than 99.5 per cent of $MgSO_4$. It contains not less than 45 per cent and not more than 52 per cent of water. Preserve it in well-closed containers.

PROPERTIES: It occurs as small, colorless needle-like prisms, without odor, and having a cooling, saline, and bitter taste. It is soluble in 0.8 part of water, almost insoluble in alcohol, and is slowly efflorescent in warm, dry air.

PREPARATION: One of the methods of making magnesium sulfate is by the action of sulfuric acid on magnesium carbonate (mineral magnesite), $MgCO_3+H_2SO_4=MgSO_4+H_2O+CO_2$.

ACTION AND USES: It is an extensively used saline cathartic. It should be given before breakfast in a saturated aqueous solution. It acts both by preventing absorption of fluid from the bowel and by drawing more fluid from the blood into the intestine. Applied externally in saturated solution on lint to swollen joints in acute arthritis, to swollen testicles in orchitis, and to boils, it relieves pain and congestion by extracting fluid from these parts. *It is the chemical antidote for poisoning by lead acetate, producing an insoluble lead sulfate, and is also used in phenol poisoning.* Magnesium sulfate can be made more pleasant to take by mixing it with sodium bicarbonate, citric acid, and tartaric acid. This mixture is known as Effervescent Salt of Magnesium Sulfate, N. F.

Average dose: 15 Gm. or 4 drams.

Magma Magnesiæ, Magnesia Magma (Milk of Magnesia), U. S. P.—It is an aqueous suspension of magnesium hydroxide containing not less than 7 per cent and not more than 8.5 per cent of $Mg(OH)_2$. For the purpose of minimizing the action of the glass container on Magnesia Magma, 0.1 per cent of citric acid may be added. One-half cc of a volatile oil or a blend of volatile oils suitable for flavoring purposes may be added to each 1,000 cc of Magnesia Magma. It should be stored in a cool place where the temperature is not above 35° C. It should not be permitted to freeze.

DESCRIPTION: A white, opaque, more or less viscous suspension from which varying amounts of water usually separate on standing. It is alkaline to litmus and to phenolphthalein test solution.

ACTION AND USES: It is used as an antacid and mild laxative and for other purposes for which magnesium oxide is used.

Average dose: 4 cc or 1 fluidram as an antacid; 15 cc or 4 fluidrams as a laxative.

Liquor Magnesii Citratis, Solution of Magnesium Citrate, U. S. P.—It contains in each 100 cc an amount of magnesium citrate corresponding to not less than 1.6 Gm. and not more than 1.9 Gm. of MgO.

DESCRIPTION: A slightly yellow, clear, effervescent liquid, having a sweet, acidulous taste, and a lemon flavor. Keep the bottle on its side in a cool place, preferably in a refrigerator.

ACTION AND USES: It is an agreeable saline purgative.

Average dose: 200 cc or 7 fluidounces (1 glassful).

Magnesii Oxidum Ponderosum, Heavy Magnesium Oxide (Heavy Magnesia), U. S. P.—Heavy Magnesium Oxide contains after ignition, not less than 96 per cent of MgO. Its loss in weight, during ignition, does not exceed 10 per cent. Preserve it in well-closed, moisture-proof containers.

DESCRIPTION: In the form of a white powder. It absorbs moisture and carbon dioxide when exposed to the air.

ACTION AND USES: Used as an antacid to neutralize excessive acidity in the gastric juice, or acidity due to fermentation in the intestines. *It is a good antidote for corrosive acid poisoning.*

Average dose: 0.25 Gm. or 4 grains as an antacid; 3.0 Gm. or 45 grains as a laxative.

Talcum Purificatum, Purified Talc, U. S. P.—A purified, native, hydrous magnesium silicate, sometimes containing a small amount of aluminum silicate.

PROPERTIES: It is a very fine white or grayish-white crystalline powder which adheres to the skin, free from grittiness and unctuous to the touch. When used as a filtering medium it should not be finer than No. 100 powder.

PREPARATION: It is prepared by treating ordinary talcum with several washings of diluted hydrochloric acid, which dissolves out aluminum, iron, and other salts of magnesium.

ACTION AND USES: It forms the base of nearly all cosmetic powders. It is an excellent dusting powder, and is used in pharmaceutical operations as a filtering medium. When perfumed or medicated, or both, it is sold as *talcum powder.*

Calcium compounds.

Calx, Lime (Calcium Oxide, Quicklime), N. F.—When freshly ignited to constant weight with a blast lamp, it contains not less than 95 per cent of CaO. It loses not more than 10 per cent of its weight on ignition. Keep lime in air-tight containers, in a dry place.

DESCRIPTION: Lime occurs in hard, white or grayish white masses or granules or a white powder. It is odorless. One gram is soluble in 840 cc of water at 25° C. and in 1,740 cc of boiling water. It is soluble in glycerin and syrup, but is insoluble in alcohol. When moistened with water, lime becomes heated and is gradually converted into a white powder (calcium hydroxide or slaked lime). When this slaked lime is mixed with about three or four times its weight of water, it forms a smooth magma (milk of lime). Water when agitated with lime becomes alkaline to litmus paper.

ACTION AND USES: Lime is used in making Solution of Sulfurated Lime, N. F. It may be used in making Lime Water, but the Pharmacopœia now provides Calcium Hydroxide for this purpose. (*See* Calcium Hydroxide.) Quick-lime (lime) is used to disinfect excreta in outdoor toilets.

Calcii Hydroxidum, Calcium Hydroxide (Slaked Lime), U. S. P.—Calcium hydroxide contains not less than 95 per cent of $Ca(OH)_2$. Preserve it in airtight containers.

DESCRIPTION: A soft, white crystalline powder, possessing an alkaline, slightly bitter taste. One gram of calcium hydroxide dissolves in 630 cc of water at 25° C., and 1 gram dissolves in 1,300 cc of water at the boiling temperature. It is soluble in glycerin and in syrup but is insoluble in alcohol. When mixed with about three or four times its weight of water, it forms a smooth paste (milk of lime).

ACTION AND USES: It is used in making Solution of Calcium Hydroxide, U. S. P.

Liquor Calcii Hydroxidi, Solution of Calcium Hydroxide (Lime Water), U. S. P.—Solution of Calcium Hydroxide is an aqueous solution containing in each 100 cc at 25° C., not less than 0.14 Gm. of $Ca(OH)_2$. The content of calcium hydroxide varies with the temperature at which the solution is stored, being about 0.17 Gm. per 100 cc at 15° C., and less at a higher temperature. Preserve it in well-filled, tightly-stoppered bottles, in a cool place.

DESCRIPTION: A clear, colorless, odorless liquid with a sweetish, alkaline taste. The solution is strongly alkaline to litmus paper. It absorbs carbon dioxide from the air, a film of calcium carbonate forming on the surface of the liquid. When heated, it becomes turbid, due to the separation of calcium hydroxide. Calcium hydroxide is less soluble in hot water than in cold water.

ACTION AND USES: Lime Water is an antacid. It is added to milk to prevent formation of large curds in the stomach, 1 part of Lime Water to 4 parts of milk. It is an antidote for corrosive acid poisoning; however, because it is a very dilute solution, a very large amount would have to be given to neutralize a considerable amount of acid.

Average dose: 15 cc or 4 fluidrams.

Calcii Chloridum, Calcium Chloride, U. S. P.—Calcium Chloride is a hydrated salt, containing not less than 75 per cent and not more than 85 per cent of $CaCl_2$. Preserve it in airtight containers.

DESCRIPTION: White, slightly translucent, hard, odorless fragments or granules. *It is very deliquescent.* One gram is soluble in 1.2 cc of water, and in about 10 cc of alcohol. An aqueous solution of the salt (1 in 20) is neutral or slightly alkaline to litmus paper.

ACTION AND USES: In internal hæmorrhage, certain bone diseases, and for lime deficiency anywhere in the body. Other salts of calcium are preferred for oral administration. It has been given intravenously in certain hæmorrhagic conditions.

Average dose: 1 Gm. or 15 grains.

Creta Præparata, Prepared Chalk, (Drop Chalk), U. S. P.—Prepared Chalk is a native form of calcium carbonate freed from most of its impurities by

elutriation, and containing, when dried to constant weight at 200° C., not less than 97 per cent of $CaCO_3$.

DESCRIPTION: A white to grayish-white, micro-crystalline powder often formed into "conical drops". It is odorless and tasteless, and is stable in the air. It is practically insoluble in water and is insoluble in alcohol.

ACTION AND USES: It is used in the preparation of Mercury with Chalk, Chalk Mixture, and Compound Chalk Powder. Prepared Chalk possesses a stickiness causing it to adhere to irritated mucous surfaces of the intestinal tract. This property accounts for its preference for internal use over Precipitated Calcium Carbonate. It is a valuable antacid. It is used in tooth powders and pastes. *It is a very good antidote for corrosive acid poisoning, particularly oxalic acid poisoning.*

Average dose: 1 Gm. or 15 grains.

Calcii Carbonas Præcipitatus, Precipitated Calcium Carbonate (Precipitated Chalk), U. S. P.—Precipitated Calcium Carbonate, when dried to constant weight at 200° C., contains not less than 98 per cent of $CaCo_3$.

DESCRIPTION: A fine, white, micro-crystalline powder, without odor or taste. It is stable in the air. It is practically insoluble in water. Its solubility in water is increased by the presence of any ammonium salt and by the presence of carbon dioxide. It is insoluble in alcohol.

ACTION AND USES: It is an antacid and detergent, but Prepared Chalk is preferred for internal use. It is used in tooth powders. It is also used in dusting powders to neutralize acid secretions. *It is the best known antidote for poisoning by oxalic acid. It is also a good antidote for poisoning by inorganic acids.*

AVERAGE DOSE: 1 Gm. or 15 grains.

Calcii Gluconas, Calcium Gluconate, U. S. P.—Calcium Gluconate is the normal calcium salt of gluconic acid. It yields not less than 12.4 per cent and not more than 12.8 per cent of CaO. Preserve in well-closed containers.

DESCRIPTION: A white, crystalline or granular powder. It is odorless, tasteless, and is stable in the air. One gram is slowly soluble in 30 cc of water. It is insoluble in alcohol. An aqueous solution (1 in 50) is neutral to litmus paper.

ACTION AND USES: It increases the blood calcium. It is used in all calcium deficiencies. It is also used before surgical operations to lessen blood coagulation time. It may be given intravenously, and by mouth. Solutions of calcium gluconate are less irritating than the chloride and are preferred for subcutaneous injection.

Average dose: 5 Gm. or 75 grains, orally; 1 Gm. or 15 grains, intravenously.

Calcii Lactas, Calcium Lactate, U. S. P.—Calcium Lactate is a hydrated salt containing not less than 25 per cent and not more than 30 per cent of water. When rendered anhydrous by drying to constant weight at 120° C., it contains not less than 98 per cent of $(CH_3.CH.OH.COO)_2Ca$. Preserve it in well-closed containers.

DESCRIPTION: A white, almost odorless powder. It is somewhat efflorescent and at 120° Co. becomes anhydrous. One gram is soluble in 20 cc of water. It is practically insoluble in alcohol.

ACTION AND USES: It increases the blood calcium. It is used for the same purpose as the gluconate.

Average dose: 1 Gm. or 15 grains.

Barium compounds.

Barii Sulfas, Barium Sulfate, U. S. P.—*In directing the use of Barium Sulfate the title should always be written out in full to avoid confusion with the poisonous barium sulfide or sulfite.*

DESCRIPTION: A fine, white, odorless, tasteless, and bulky powder, free from grittiness. It is insoluble in water, in organic solvents and in aqueous solutions of acids and of alkalies.

ACTION AND USES: It is used in making X-ray pictures of the stomach and intestine. It passes unchanged through the gastro-intestinal tract. It should be remembered that soluble salts of barium are poisonous. Barium Sulfate is nonpoisonous because it is insoluble in water or in the juices of the intestinal tract. The New and Nonofficial Remedies describes the method of administration as follows:

"*For Roentgen Examination of the Stomach.*—The evening before the examination, the patient receives 1 fluidounce of castor oil. In the morning an ordinary portion of wheat-meal porridge, with which 2 ounces of barium sulfate has been well mixed, together with a little sugar and cream, is administered by mouth. The patient is then directed to abstain from further food. The examination is made 6 hours later.

"*For Roentgen Examination of the Colon.*—An enema consisting of 16 ounces of mucilage of acacia, 3 pounds of condensed milk, and 8 ounces of barium sulfate is warmed to body temperature and injected into the rectum from a height of from 3 to 6 feet (90 to 180 cm). The examination is made with a fluoroscope while the injection is passing into the rectum."

Zinc compounds.

Zinci Oxidum, Zinc Oxide, ZnO, U. S. P.—It contains, when freshly ignited, not less than 99 per cent of ZnO.

PROPERTIES: It is a very fine, amorphous, white or yellowish-white powder, free from gritty particles, without odor or taste. It gradually absorbs carbon dioxide from the air; is insoluble in water or alcohol, but soluble in ammonia and ammonium carbonate test solutions, and in dilute acids.

PREPARATION: It is made by calcination of pure zinc carbonate: $2ZnCO_3.3Zn(OH)_2 + heat = 5ZnO + 3H_2O + 2CO_2$.

ACTION AND USES: Zinc oxide is a nontoxic protective and is mildly astringent and slightly antiseptic. It may be employed either in the form of a dusting powder, in a paste, in an ointment, or suspended in an aqueous mixture. The most popular of these is zinc-oxide ointment, which is composed of 20 per cent zinc oxide, 10 per cent liquid petrolatum, 5 per cent wool fat, 5 per cent white wax, and 60 per cent white petrolatum.

Zinci Sulfas, Zinc Sulfate (White Vitriol), $ZnSO_4+7H_2O$, U. S. P.—It contains not less than 55.86 per cent nor more than 58.63 per cent of zinc sulfate, corresponding to not less than 99.5 per cent of the hydrated salt ($ZnSO_4+7H_2O$). Preserve it in well-closed containers.

PROPERTIES: It occurs in colorless, transparent prisms, or small needles, or as a granular, crystalline powder, odorless, and having an astringent and metallic taste. It is efflorescent in dry air. Soluble in 0.6 parts of water, 2.5 parts of glycerin, and insoluble in alcohol. An aqueous solution is acid to litmus paper.

PREPARATION: Made by treating metallic zinc with diluted sulfuric acid; $Zn+H_2SO_4=ZnSO_4+H_2$.

ACTION AND USES: It is employed as an astringent and emetic. A weak aqueous solution 1–400 may be used as an eye wash, gargle, or urethral injection in gonnorhœa. It acts as a prompt emetic in 15-grain doses but as other drugs are preferred, it seldom is used. It is used in the Navy principally as an astringent eye wash, 1 grain dissolved in 1 fluidounce of distilled water.

Average dose: 1 Gm. or 15 grains. (As an emetic.)

Calamina Præparata, Prepared Calamine, N. F.—Prepared Calamine is zinc oxide with a small amount of ferric oxide, and contains, after ignition, not less than 98 per cent of ZnO.

DESCRIPTION: Prepared Calamine is a pink powder which will pass through a number 100 sieve. It is odorless and almost tasteless. It is insoluble in water but dissolves almost completely in mineral acids.

ACTION AND USES: It is mildly astringent and soothing when applied to the inflamed skin. It is used in ointments, lotions, and powders.

Zinci Chloridum, Zinc Chloride, U. S. P.—Zinc Chloride contains not less than 95 per cent of $ZnCl_2$. Preserve it in glass-stoppered bottles.

DESCRIPTION: A white, or nearly white, odorless, crystalline powder, or in porcelain-like masses, or molded into pencils. *It is very deliquescent.* One gram is soluble in 0.25 cc of water, and in about 1.3 cc of alcohol. It is soluble in 2 parts of glycerin. An aqueous solution of the salt (1 in 10), is acid to litmus paper. Solutions of Zinc Chloride when diluted with much water become turbid, owing to hydrolysis. This turbidity disappears upon the addition of a small quantity of hydrochloric acid.

ACTION AND USES: It is antiseptic, astringent, and escharotic. Solution of Zinc Chloride should be filtered through glass wool, because it dissolves paper filters. If an eye solution of zinc chloride becomes turbid it should not be cleared up with hydrochloric acid. The antidote for zinc chloride poisoning is sodium bicarbonate followed by milk or white of egg. A 1 to 2 per cent solution is used as a dental astringent and antiseptic. It is not given internally.

Zinci Stearas, Zinc Stearate, U. S. P.—Zinc Stearate is a compound of zinc with variable proportions of stearic acid and palmitic acid, corresponding to not less than 13 per cent and not more than 15.5 per cent of ZnO.

DESCRIPTION: A fine, white, bulky powder, free from grittiness, and having a faint, characteristic odor. It is insoluble in water and in alcohol.

ACTION AND USES: Used as an infant dusting powder but must be used with care to avoid inhalation of the fine dust, which is toxic, causing inflammation of the baby's lungs. It is also used in ointments.

Aluminum compounds.

Alumen, Alum, U. S. P.—It contains not less than 99.5 per cent of $AlNH_4(SO_4)_2+12H_2O$; or $AlK(SO_4)_2+12H_2O$. The label of the container must indicate whether the salt is ammonium alum or potassium alum.

PROPERTIES: It occurs as large, colorless crystals, crystalline fragments, or as a white powder, odorless, and having a sweetish, strongly astringent taste. Soluble in 5.2 to 7.2 parts of water, insoluble in alcohol, and fairly soluble in glycerin. Potassium alum is more soluble in water than ammonium alum. An aqueous solution of alum is acid to litmus. Ammonium alum can be distinguished from potassium alum by heating a small quantity of a sample with lime. If it is ammonium alum, ammonia will be set free from the mixture. When a hot concentrated solution of alum is poured into a hot concentrated solution of an alkaline carbonate the carbonate is decomposed with the liberation of CO_2 (similar to the action of an acid on a carbonate). This reaction is taken advantage of in the manufacture of cheap baking powders; alum mixed with sodium bicarbonate is mixed with the dough used in making bread. When the dough begins to bake the reaction starts, liberating CO_2 which, in rising, carries the dough with it for a certain distance.

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PREPARATION: Made principally from aluminum clay (silicate) by treatment with sulfuric acid and then adding potassium or ammonium sulfate, forming the double salt.

ACTION AND USES: It is used as an astringent both internally and externally. Used as a local styptic in epistaxis, external hæmorrhages and bleeding from mucous membranes, to which the powder can be applied drectly. In nosebleed a saturated solution on pledgets of cotton sometimes is used in the nares. Barbers use it for bleeding caused by shaving. When powdered it is used as an emetic. Alum is used in making exsiccated alum U. S. P. (burnt alum), which is alum deprived of its water of crystallization. The properties of exsiccated alum are the same as those of alum except that they are more intensified.

Average dose: 0.5 Gm., or 8 grains.

Alumen Exsiccatum, Exsiccated Alum (Burnt Alum), U. S. P.—Exsiccated Alum, when recently dried to constant weight at 200° C., contains not less than 96.5 per cent of Ammonium Alum ($AlNH_4(SO_4)_2$) or of Potassium Alum ($AlK(SO_4)_2$). The label of the container must indicate whether the Exsiccated Alum was made from Ammonium Alum or Potassium Alum. Preserve it in airtight containers.

DESCRIPTION: A white, odorless power. It has a sweetish, astringent taste, and absorbs moisture on exposure to air.

ACTION AND USES: It is almost twice as strong as Alum, U. S. P., which contains water of crystallization. Its astringent and caustic action is due largely to its great affinity for water. It is used by barbers to stop bleeding caused by razor cuts. It is not given internally.

Iron compounds.

Iron forms two series of chemical compounds, in one of which it has a valence of three and the compounds are known as ferr*ic*; in the other it has a valence of two and the compounds are known as ferr*ous*. The ferric compounds are distinguished by their brown color, the ferrous compounds are green. The ferric compounds are fairly stable; the tendency of the ferrous compounds is to change to the ferric condition, especially in the presence of oxidizing agents. The ferric compounds are oxidizing agents; the ferrous compounds are reducing agents. Ferrous compounds are made by the action of an acid on an electronegative element, such as iodine, on metallic iron, excluding the air (oxygen), which is an oxidizing agent, to prevent oxidation to the ferric state. Ferric compounds are made by oxidizing ferrous compounds. The principal effect of iron on the system is that it increases the amount of hæmatin in the hæmoglobin of the blood resulting in an improvement in the functions of the various organs of the body, to which its tonic effect is due. Both locally and internally iron acts as an astringent. The astringent properties of the different compounds vary, some being very active while others are very mild. Most of the compounds of iron are soluble in water. The oxide, hydroxide, and carbonate are insoluble.

Tinctura Ferri Chloridi, Tincture of Ferric Chloride (Tincture of Iron), U. S. P.—A hydroalcoholic solution containing in each 100 cc, about 13 per cent of ferric chloride ($FeCl_3$), corresponding to not less than 4.5 per cent of Fe. Protect tincture of ferric chloride from light, in a cool place, in glass stoppered bottles.

PROPERTIES: A bright, amber-colored liquid, having a slightly ethereal odor, a very astringent, styptic taste, and an acid reaction.

PREPARATION: It is made by diluting 350 cc of solution of ferric chloride with sufficient alcohol to make 1,000 cc.

ACTION AND USES: It should be administered well diluted with water, and taken through a glass tube. The mouth should be thoroughly rinsed to avoid

injury to the teeth. It is a valuable chalybeate (iron) tonic and styptic. It also has slight diuretic properties. It is used in making solution of iron and ammonium acetate (Basham's mixture), N. F.

Average dose: 0.5 to 2 cc or 8 to 30 minims.

Tincture of Ferri Citrochloridi, Tincture of Ferric Citrochloride (Tasteless Tincture of Ferric Chloride, Tasteless Tincture of Iron), N. F.—It is a hydroalcoholic solution made by dissolving sodium citrate in solution of ferric chloride and adding a small amount of alcohol and much water. It resembles in properties the scale salts of iron, except that it is a solution. It contains, in each 100 cc, ferric citrochloride equivalent to not less than 4.48 Gm. of Fe.

ACTION AND USES: It is used in making Elixir of Iron, Quinine, and Strychnine, N. F. Its medicinal properties are practically the same as those of tincture of ferric chloride, U. S. P., except that it is milder.

Average dose: 0.5 cc, or 8 minims.

Magma Ferri Hydroxidi, Magma of Ferric Hydroxide (Arsenic Antidote), U. S. P.—This preparation is used only as a chemical antidote for poisoning by arsenic.

PREPARATION: Forty cc of Solution of Ferric Sulfate is mixed with 125 cc of distilled water and placed in a large, well-stoppered bottle. Ten Gm. of Magnesium Oxide is rubbed with cold water to a smooth, thin mixture, placed in a bottle capable of holding 1,000 cc, and 750 cc of distilled water then added. When needed, shake the mixture of magnesium oxide to a thin, creamy consistence, slowly add the diluted solution of ferric sulfate, and shake together until a uniformly smooth mixture results.

A solution of Sodium Carbonate or Milk of Magnesia added to Tincture of Ferric Chloride, and the precipitate strained through cheesecloth, may be used if the official antidote is not available.

ACTION AND USES: The antidotal action of this preparation is presumably due to the adsorption of arsenic. It is efficient only when freshly prepared, and, as it must be administered promptly, the two solutions should always be on hand ready for use.

Average dose: 120 cc or 4 fluidounces.

Pilulæ Ferri Carbonatis, Pills of Ferrous Carbonate (Blaud's Pills), U. S. P.—Each pill contains not less than 0.06 gram (1 grain) of $FeCO_3$.

PREPARATION: Made by the action of potassium carbonate on ferrous sulfate, $FeSO_4+K_2CO_3=FeCO_3+K_2SO_4$. The pills do not keep unless well coated to exclude oxygen. If kept on hand for a long time the ferrous carbonate is changed to the ferric state. When these pills are made in the dispensary they should be used as soon as possible after their preparation. They never should be prepared and kept in stock for issue, or dispensed if they are reddish-brown in color within. These pills are on the Supply Table, in tablet form, chocolate coated.

ACTION AND USES: Valuable iron tonic. Used in the treatment of anæmias.

Average dose: 3 pills.

Ferri et Ammonii Citrates Virides, Green Iron and Ammonium Citrates, U. S. P.—Green iron and Ammonium Citrates contains ferric citrate equivalent to not less than 14.5 per cent and not more than 16 per cent of Fe. Preserve it in well-closed containers and protected from light.

DESCRIPTION: Thin, transparent, green scales or granules. It is odorless and has a saline, mildly ferruginous taste. It is deliquescent in air, readily soluble in water, and insoluble in alcohol. An aqueous solution of the salt (1 in 20) is acid to litmus paper.

ACTION AND USES: It is a suitable compound of iron for hypodermic administration.

Average dose: 0.015 to 0.1 Gm. or ¼ to 1½ grains. (By parenteral injection.)

Arsenic compounds.

Arseni Trioxidum, Arsenic Trioxide (White Arsenic), U. S. P.—When dried to constant weight at 100° C., it contains not less than 99.8 per cent of As_2O_3. Powdered Arsenic Trioxide when administered in solid form, as in powders, tablets, and pills must consist of particles not greater than 0.0125 mm. in diameter.

Properties: A white powder, or irregular masses of two varieties, one amorphous, transparent and colorless, like glass; the other crystalline, opaque and white, resembling porcelain. Frequently the same piece has an opaque, white outer crust enclosing the glassy variety. Contact with moist air gradually changes the glassy into the white, opaque variety. All varieties are odorless. It is slowly soluble in water, freely soluble in glycerin, and slightly soluble in alcohol. It is dissolved by hydrochloric acid and by solutions of alkali carbonates. Caution: *Arsenic trioxide is extremely poisonous.*

Actions and Uses: It irritates the mucous membrane of the stomach and intestine. Toxic doses cause nausea, vomiting, colicky pains in abdomen, watery diarrhœa, fatty degeneration of the liver and other organs. Large doses produce great depression and collapse. It is thought that arsenic stimulates the action of the blood-forming organs, especially the bone marrow, and for this reason is considered useful in the treatment of anæmia. Some skin conditions such as psoriasis and chronic eczema are apparently improved by proper doses of arsenic. The physiological effect of arsenic is due to the arsenic trioxide ion and not to the element arsenic. In cases of poisoning, wash out the stomach and give large doses of Magma of Ferric Hydroxide, U. S. P.

Average dose: 0.002 Gm. or 1/30 grain.

Liquor Potassii Arsenitis, Solution of Potassium Arsenite (Fowler's Solution), U. S. P.—An aqueous solution of potassium arsenite containing in each 100 cc the equivalent of not less than 0.950 Gm. nor more than 1.050 Gm. of As_2O_3. Preserve the solution in amber-colored bottles.

Properties: A clear, colorless liquid, alkaline to litmus.

Preparation; It is made by boiling together potassium bicarbonate and arsenic trioxide in the proportion to give a finished solution having the given strength. It is held that the following reaction takes place: $As_2O_3+4KHCO_3 = 2K_2HAsO_3+H_2O+4CO_2$.

Action and Uses: It is a useful remedy against protozoal affections. Used in the treatment of malaria and relapsing fever; in the treatment of certain chronic skin affections such as psoriasis, lichen planus, chronic eczema, chronic urticaria, etc. It stimulates the action of the blood-forming organs, especially the bone marrow, by its alterative and tonic properties. *It is a poison and must be handled with great care.*

Average dose: 0.2 cc or 3 minims, diluted with water.

Arsphenamina, Arsphenamine (Diaminodihydroxyarsenobenzol hydrochloride), U. S. P.—Also known as salvarsan, 606, arsenobenzol and arsaminol. Contains not less than 30 per cent of arsenic (As). Its manufacture is under the control of the U. S. Public Health Service.

Properties: A light yellow, hygroscopic powder, very unstable in air, and put up in sealed ampules.

Action and Uses: A specific remedy for syphilis in all stages, but it is more efficient the more recent the infection; also useful in various spirillum diseases, such as relapsing fever, Vincent's angina, etc.

Average dose: 0.3 to 0.6 Gm. or 5 to 9 grains, administered intravenously.

Neoarsphenamina, Neoarsphenamine (Neosalvarsan), U. S. P.—The name applied to a mixture, sodiumdiaminodihydroxyarsenobenzenemethanolsulfoxylate

with inert, inorganic salts. It contains not less than 19 nor more than 22 per cent of arsenic (As) and complies with the requirements of the National Institute of Health, U. S. Public Health Service. Preserve it in sealed tubes of colorless glass, from which the air has been excluded either by the production of a vacuum or by displacement with a nonoxidizing gas, *in a cool place, preferably not above 10° C.*

PROPERTIES: A yellow powder, and is very unstable in air.

ACTION AND USES: Essentially the same as those of arsphenamine, although many observers claim better results. It differs from arsphenamine in that it dissolves readily in sterile water, making a neutral solution which can at once be injected. Water not warmer than from 20° to 22° C. (68° to 71.6° F) should be used in dissolving the drug and the injections should be made at once, as it oxidizes rapidly and becomes toxic. The solution should not be shaken and it must not be administered subcutaneously.

Average dose: 0.6 to 0.9 Gm. or 9 to 14 grains.

Tryparsamidum, Tryparsamide, U. S. P.—It contains not less than 25.1 and not more than 25.5 per cent of arsenic (As) when dried to constant weight at 110° C.

PROPERTIES: A white, odorless, crystalline powder. One gram is soluble in 2 cc of water. It is slightly soluble in alcohol. It should be preserved in well-closed containers protected from light. The arsenic in this compound is pentavalent (having a valence of five).

ACTION AND USES: It is used in the treatment of syphilis of the central nervous system where arsphenamine and neoarsphenamine have failed to produce favorable results. It is given intravenously, intramuscularly, or subcutaneously dissolved in distilled water or salt solution. It was first used in the treatment of trypanosomiasis.

Average dose: 2 Gm. or 30 grains (CAUTION: *Never give by mouth*).

The directions on the package should be followed in its administration.

Sulfarsphenamine, N. N. R.—It contains 19 to 24 per cent of arsenic in the trivalent form.

PROPERTIES: It is an orange-yellow powder possessing an odor resembling that of sulfur dioxide and arsine. It is readily soluble in water yielding a yellow solution which is acid to litmus.

ACTION AND USES: It is used in the treatment of syphilis where it is desired to administer arsenicals intramuscularly. It may also be given by subcutaneous injection.

Average dose: 0.4 Gm. or 6 grains (intramuscularly).

Antimony compounds.

Antimonii et Potassii Tartras, Antimony and Potassium Tartrate (Antimonyl Potassium Tartrate, Tartrated Antimony, Tartar Emetic), U. S. P.—It contains not less than 99 per cent of $KOOC.CHOH.CHOH.COO(SbO)+\frac{1}{2}H_2O$. Preserve it in well-closed containers.

PROPERTIES: Occurs as a white, granular powder or colorless, transparent crystals. Disagreeable metallic taste, odorless. The crystals effloresce on exposure to air. Soluble in 12 parts of cold water, 3 parts of boiling water, 15 parts of glycerin, and insoluble in alcohol. Its aqueous solution is slightly acid to litmus paper.

PREPARATION: It is made by boiling antimony oxide with potassium bitartrate. $2KHC_4H_4O_6+Sb_2O_3=2K(SbO)C_4H_4O_6+H_2O$.

ACTION AND USES: It is used chiefly as an expectorant and a diaphoretic, rarely as an emetic, and is of value in African sleeping sickness. It is one

of the ingredients in Compound Mixture of Opium and Glycyrrhiza, U. S. P. (Brown Mixture).

Average dose: 0.003 Gm. or 1/20 grain.

Bismuth compounds.

Bismuthi Subnitras, Bismuth Subnitrate, U. S. P.—A basic bismuth nitrate of varying chemical composition, which, when dried for 24 hours in a desiccator over sulfuric acid, yields, upon ignition, not less than 79 per cent of bismuth oxide (Bi_2O_3). Preserve it in well-closed containers protected from light.

Properties: A heavy white powder, odorless, tasteless, and slightly hygroscopic. Almost insoluble in water and insoluble in alcohol, readily soluble in hydrochloric or nitric acid. It is slightly acid in reaction.

Preparation: It is made by dissolving metallic bismuth in nitric acid and treating the resulting solution with sodium carbonate which precipitates the bismuth as subcarbonate (here the bismuth is freed from arsenic); the subcarbonate is redissolved with nitric acid, forming bismuth nitrate, which is converted to the subnitrate by treatment with ammonia water; the precipitate then is collected, washed, and dried.

Action and Uses: It is used internally in the treatment of gastric and intestinal disorders as a sedative astringent, especially in diarrhœa and putrefactive conditions. In large doses it coats the mucous membranes of the intestine and acts as a protective. Very large doses are given in X-ray work for the purpose of outlining the stomach and intestine. However, bismuth subcarbonate is better than the subnitrate for this purpose because it is less toxic. When applied to wounds or mucous membranes it acts as a protective, astringent, and antiseptic. It is also given by parenteral injection in the treatment of syphilis.

Average dose: 1 Gm. or 15 grains; 0.125 Gm. or 2 grains as antisyphilitic.

Bismuthi Subcarbonas, Bismuth Subcarbonate (Basic Bismuth Carbonate), U. S. P.—It is a basic salt, which, when dried to constant weight at 100° C., yields upon ignition not less than 90 per-cent of Bi_2O_3. Protect it from the light in well-closed containers.

Properties: A white or pale yellowish-white powder. It is odorless and tasteless, and is stable in the air. It is insoluble in water and in alcohol.

Action and Uses: It is protective, slightly antiseptic, astringent, and antacid. It is used in the treatment of hyperacidity of the stomach and in the treatment of ulcers of the stomach and intestine. It is used in making X-ray pictures of the intestinal tract. It is less toxic than the subnitrate and may be given in larger doses with greater safety. It is used as an antiseptic and protective application in the treatment of skin diseases, old ulcers, and suppurating wounds. Its external application to the broken skin must be watched for possible toxic symptoms due to absorption of the drug.

Average dose: 1 Gm. or 15 grains.

Bismuthi Subsalicylas, Bismuth Subsalicylate (Basic Bismuth Salicylate), U. S. P.—It is a basic salt containing not less than 62 per cent and not more than 66 per cent of Bi_2O_3 when dried to constant weight at 100° C. Preserve it in well-closed containers protected from light.

Properties: A white, or nearly white, amorphous or crystalline powder. It is odorless and is stable in the air. It is practically insoluble in water.

Action and Uses: It is given intramuscularly in the treatment of syphilis. It is administered suspended in oil. The preparation on the Supply Table known as Bismuth Subsalicylate in Oil contains 0.13 Gm. of Bismuth Subsalicylate in each cubic centimeter of the mixture when thoroughly mixed by shaking. The oil is composed of 10 per cent camphor, 10 per cent creosote, and

80 per cent olive oil. One cubic centimeter of this mixture is given each week until eight doses have been given.

Average dose: 0.125 Gm. or 2 grains (intramuscularly).

Bismuthi et Potassii Tartras, Bismuth and Potassium Tartrate, U. S. P.—It is a basic bismuth potassium bismuthotartrate containing the equivalent of not less than 71 per cent and not more than 75 per cent of Bi_2O_3. Preserve it in well-closed containers protected from light.

PROPERTIES: A granular, white, odorless powder, having a sweetish taste. It darkens on exposure to light. One grain is soluble in 2 cubic centimeters of water.

ACTION AND USES: It is given intramuscularly in the treatment of syphilis. A similar preparation is on the Supply Table by the name "Solution of Potassium and Sodium Bismuthotartrate (Bismosol)".

Average dose: 0.15 Gm. or 2½ grains (intramuscularly).

Thio-Bismol, Sodium Bismuth Thioglycollate, N. N. R.—A salt formed by the interaction of sodium thioglycollate and bismuth hydroxide. It contains about 38 per cent of bismuth.

PROPERTIES: It is a canary yellow, hygroscopic, noncrystalline but granular substance possessing a garlic-like odor. It is freely soluble in water but the solutions are not stable. It is on the Supply Table in the form of a 0.2 Gm. ampule which is to be dissolved in 1 cubic centimeter of sterile distilled water before administration.

ACTION AND USES: It is used in the treatment of syphilis. It is a water soluble compound, readily absorbable, and produces very little local injury when injected.

Average dose: 0.2 Gm. or 3 grains, administered intramuscularly twice a week for a series of 12 doses.

Lead compounds.

Plumbi Acetas, Lead Acetate (Sugar of Lead), U. S. P.—It contains not less than 85.31 per cent nor more than 89.57 per cent of anhydrous lead acetate, corresponding to not less than 99.5 per cent of the hydrated salt $(CH_3.COO)_2Pb+3H_2O$. Preserve it in well-closed containers.

PROPERTIES: It occurs as colorless, shining, transparent prisms or plates, or heavy, white, crystalline masses, or granular crystals, faintly acetous odor, and is efflorescent and absorbs carbon dioxide from the air; therefore it must be kept in well-closed containers. It is soluble in 1.6 parts of water, about 30 parts of alcohol, and is freely soluble in glycerin. An aqueous solution is slightly alkaline to litmus.

PREPARATION: It is made by adding lead oxide to acetic acid and gently heating the mixture until combination takes place. $PbO+2HC_2H_3O_2=Pb(C_2H_3O_2)_2+H_2O$.

ACTION AND USES: It is used internally combined with opium (lead and opium pill containing 1 grain each), as a sedative astringent in diarrhœa. It is used in the preparation of Lotion of Lead and Opium, N. F., which is used externally as a sedative astringent application to sprains and bruises. A 1 per cent solution in alcohol is used externally for ivy poisoning. *It is a very poisonous drug. The best antidote is magnesium sulfate which forms with the lead acetate an insoluble lead sulfate. The lead sulfate so formed must be washed out of the stomach with a stomach tube.*

Average dose: 0.06 Gm. or 1 grain.

Mercury compounds.

Hydrargyrum, Mercury (Quicksilver), Hg, U. S. P.—It contains not less than 99.5 per cent of Hg. Preserve it in strong, well-closed containers.

PROPERTIES: A shining, silver-white, metal, liquid at ordinary temperatures. It solidifies at —38.8° C. and boils at 358° C. Its specific gravity is 13.596. Insoluble in ordinary solvents, but readily soluble in nitric acid. Mercury forms two series of compounds: Mercur*ous*, in which mercury has a valence of one, and merur*ic*, in which it has a valence of two.

PREPARATION: It is made by roasting sulfide of mercury (cinnabar), forming mercury and sulfur dioxide.

ACTION AND USES: In its massive form mercury has very little action on the system, but when reduced to a fine state of subdivision it is capable of absorption either by the skin or mucous membranes and produces the physiological effects of its salts. It is contained in a fine state of subdivision, diluted with various vehicles in the following preparations: Mercury with Chalk, U. S. P.; Mass of Mercury, U. S. P.; Strong Mercurial Ointment, U. S. P.; Mild Mercurial Ointment, U. S. P.

Hydrargyrum Ammoniatum, Ammoniated Mercury (White Precipitate), $HgNH_2Cl$, U. S. P.—It contains mercurammonium chloride ($HgNH_2Cl$) corresponding to not less than 78 per cent nor more than 80 per cent of Hg. Preserve it in well-closed containers, protected from light.

PROPERTIES: A white, amorphous powder, odorless, and having an earthy, afterwards styptic metallic taste; permanent in the air; insoluble in water or alcohol.

PREPARATION: Made by precipitating a solution of mercuric chloride with ammonia water. $HgCl_2+2NH_4OH=HgNH_2Cl+2H_2O+NH_4Cl$.

ACTION AND USES: *Taken internally it acts as an irritant poison.* It is used externally in the form of an ointment (from 2 to 10 per cent) in the treatment of parasitic skin diseases. It acts as an antiseptic and local stimulant.

Hydrargyri Bichloridum, Mercury Bichloride (Corrosive Sublimate, Corrosive Mercuric Chloride, Bichloride of Mercury), $HgCl_2$, U. S. P.—When dried for 24 hours over sulfuric acid, it contains not less than 99.5 per cent of $HgCl_2$. Preserve it in well-closed containers.

DESCRIPTION: Heavy, colorless, odorless crystals or crystalline masses, or a white powder. One gram is soluble in 13.5 cc of water, in 3.8 cc of alcohol, in about 12 cc of glycerin, and in 22 cc of ether. An aqueous solution of mercury bichloride (1 in 20) is acid to litmus paper, but becomes neutral upon the addition of sodium chloride. When heated it volatilizes. CAUTION: *Mercury Bichloride is extremely poisonous.*

ACTION AND USES: As an antiseptic application to the skin it may be used in strengths varying from 1–1,000 to 1–5,000 dissolved in water. The injection of bichloride solution into body cavities or its application to raw surfaces should be done with great caution. When used for irrigation of the vagina it may be absorbed in sufficient quantity to produce poisoning. A solution of bichloride corrodes instruments. If an aqueous solution of bichloride is exposed to light it undergoes partial decomposition with precipitation of calomel. This may be prevented by the addition of a few drops of hydrochloric acid or ammonium chloride. Bichloride in solution with potassium iodide is given by mouth and it is also injected intramuscularly in the treatment of syphilis. Poisoning by bichloride, taken by mouth, is treated by immediate administration of whites of eggs followed by emetic and washing out the stomach. *See* section on Toxicology.

Average dose: 0.004 Gm. or 1/15 grain.

Hydrargyri Chloridum Mite, Mild Mercurous Chloride, (Calomel, Mercurous Chloride, Protochloride of Mercury, Subchloride of Mercury), HgCl, U. S. P.—

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99.6 per cent of HgCl. Preserve it in well-closed containers, protected from light.

PROPERTIES: It is a heavy, white, impalpable powder, turning yellowish white on being triturated with pressure; odorless, tasteless, and permanent in the air. Insoluble in water, alcohol, ether, or cold diluted acids. It should not contain the slightest trace of bichloride of mercury. It undergoes changes when exposed to light, or in contact with alkaline chlorides, bromides, or iodides, resulting in the production of mercuric salts which are toxic.

PREPARATION: The process for making calomel is similar to that for making bichloride except that metallic mercury is added. Mercury, mercuric sulfate, and sodium chloride are heated together in a retort, resulting in the formation of calomel, which is sublimed and condensed in a separate container. $Hg+HgSO_4+2NaCl=2HgCl+Na_2SO_4$. After sublimation the calomel is washed several times with distilled water to free it from bichloride of mercury.

ACTION AND USES: Used externally as an antiseptic dusting powder and in ointments (33⅓ per cent) as a venereal prophylactic. Internally it is used as an alterative, cathartic, and diuretic. When calomel is given for its purgative effect it should be followed from 4 to 6 hours after administration by a normal dose of Epsom salt.

Average dose: Laxative 0.15 Gm. or 2.5 grains; alterative 0.015 Gm. or ¼ grain.

Hydrargyri Oxidum Flavum, Yellow Mercuric Oxide, U. S. P.—It contains, when dried to constant weight at 110° C., not less than 99.5 per cent of HgO. Preserve it in well-closed containers, *protected from light.*

PROPERTIES: An orange-yellow, heavy, impalpable powder; odorless and having a metallic taste; turns darker on exposure to light, and is almost insoluble in water; insoluble in alcohol.

PREPARATION: Made by precipitating a solution of mercuric chloride with sodium hydroxide: $HgCl_2+2NaOH=HgO+H_2O+2NaCl$.

ACTION AND USES: It is not given internally. In the form of an ointment it is used in the treatment of inflammation of the eyelids. Yellow Mercuric Oxide Ointment, U. S. P., contains 1 per cent of mercuric oxide.

Hydrargyri Salicylas, Mercuric Salicylate (Mercuric Subsalicylate), U. S. P.—A compound of mercury and salicylic acid containing not less than 54 per cent nor more than 59.5 per cent of Hg. Preserve it in well-closed containers protected from light.

PROPERTIES: A white or slightly yellow or slightly pink powder; odorless and tasteless; insoluble in water or alcohol. Soluble in warm solutions of alkali halides forming double salts.

PREPARATION: It may be made by heating yellow mercuric oxide with salicylic acid and a little water until a white mixture results.

ACTION AND USES: Used in the treatment of syphilis. It is given intramuscularly suspended in neutral oil (1 grain to 10 minims of oil). It possesses the advantage of being less irritant than the other salts of mercury, both to the intestinal tract and when given intramuscularly. It is absorbed slowly.

Average dose: 0.06 Gm. or 1 grain.

Toxitabellæ Hydrargyri Bichloridi Magnæ, Large Poison Tablets of Mercury Bichloride, U. S. P.—Each tablet contains an average of not less than 0.45 Gm. and not more than 0.55 Gm. of $HgCl_2$, with a sufficient quantity of a suitable excipient or diluent.

These tablets must be of a distinctive color, not white; they must be of an angular or irregular shape, not discoid. When sold in small quantities suitable

for household use, they must be dispensed in glass containers of a distinctive, angular shape having irregular or roughened sides or edges. On the exterior of each container must be placed a red printed label bearing the word "POISON", and a statement indicating the amount of mercury bichloride in each tablet.

USES: These tablets are used for convenient preparation of bicholoride solution. One tablet dissolved in 500 cc of water makes a 1 in 1,000 solution.

Toxitabellæ Hydrargyri Bichloridi Parvæ, Small Poison Tablets of Mercury Bichloride, U. S. P.—Each tablet contains an average of not less than 0.1125 Gm. and not more than 0.1375 Gm. of $HgCl_2$, with a sufficient quantity of a suitable excipient or diluent.

These tablets must be of a distinctive color, not white; they must be of an angular or irregular shape, not discoid. When sold in small quantities suitable for household use, they must be dispensed in glass containers of a distinctive angular shape having irregular or roughened sides or edges. On the exterior of each container must be placed a red printed label bearing the word "POISON", and a statement indicating the amount of mercury bichloride in each tablet.

USES: These tablets are used for convenient preparation of small quantities of bichloride solution. One tablet dissolved in 500 cc of water makes a 1 in 4,000 solution.

Unguentum Hydrargyri Forte, Strong Mercurial Ointment, U. S. P.—It contains not less than 49 per cent and not more than 51 per cent of Hg. The globules of mercury should be so fine that they are not visible under a lens magnifying 10 diameters. The base is composed of oleate of mercury, white wax, wool fat, and petrolatum. It is used in the preparation of Mild Mercurial Ointment.

ACTION AND USES: It is rubbed into the skin in the treatment of syphilis. Four grams of the ointment should be rubbed into a selected area of the skin at night and the part should be cleaned in the morning. A new area should be selected for inunction the following night to avoid irritation of the skin. If the ointment is irritating it should be diluted with wool fat.

Unguentum Hydrargyri Mite, Mild Mercurial Ointment (Blue Ointment), U. S. P.—It contains not less than 29 per cent and not more than 31 per cent of Hg. In each 100 Gm. there are 60 Gm. of Strong Mercurial Ointment, 2 Gm. of white wax, and 38 Gm. of white petrolatum.

ACTION AND USES: It is a paraciticide and is rubbed on the skin to destroy lice.

Hydrargyri Oxycyanidum, Mercuric Oxycyanide, $Hg(CN)_2 HgO$, N. N. R.—It is a basic mercuric salt of hydrocyanic acid containing from 51.7 to 56 per cent of mercuric cyanide ($Hg(CN)_2$) and from 44.3 to 48.0 per cent of mercuric oxide (HgO). Protect it from light in well-closed bottles.

PROPERTIES: It is a white or nearly white, microcrystalline powder. One part is soluble in 80 parts of water yielding a solution which is alkaline to litmus paper.

ACTION AND USES: It is an antiseptic which does not precipitate albumin, and in dilute solution does not attack surgical instruments. It is used in the disinfection of surgical instruments that cannot be boiled. It is used in genito-urinary work for the disinfection of cystoscopes, 1 part of mercuric oxycyanide to 1,000 parts of water.

Mercurochrome, Mercurochrome soluble, N. N. R.—It is the disodium salt of dibromohydroxymercurifluorescein containing 24 to 26 per cent of mercury.

PROPERTIES: It occurs as iridescent, green scales or granules, odorless, and permanent in the air. It is freely soluble in water and practically insoluble in alcohol. The aqueous solution is stable in the air, does not precipitate proteins and does not respond to the usual tests for mercury ions.

ACTION AND USES: It is nonirritating, moderately active, antiseptic. It stains the skin red. The stains can be removed by washing with sodium hypochlorite solution or 3 per cent hydrochloric acid in alcohol. Mercurochrome Solution (Scott's Solution) for disinfection of the skin before operation is composed of 2 parts mercurochrome, 35 parts distilled water, 55 parts alcohol, and 10 parts acetone.

Merthiolate, Merthiolate Sodium, Sodium Ethylmercuri Thiosalicylate, N. N. R.—Merthiolate contains about 49 per cent of mercury in organic combination.

PROPERTIES: It is a light, cream colored, crystalline powder, having a slight odor. It is stable in air but unstable in sunlight. One part is soluble in 1 part of water, or in 8 parts of alcohol.

ACTION AND USES: It has high germicidal potency against spore-bearing and non-spore-bearing bacteria and is also a fungicide. It does not precipitate with serum proteins and does not irritate. For disinfection of the skin use 1 in 1,000 alcoholic solution; for wounds use 1 in 1,000 water solution; for instruments use 1 in 1,000 water solution.

Silver compounds.

Argenti Nitras, Silver Nitrate, AgNo$_3$, U. S. P.—It contains, when powdered and dried to constant weight in a desiccator over sulfuric acid, in the dark, not less than 99.8 per cent of $AgNO_3$. Preserve it in dark amber-colored, glass-stoppered vials, protected from light.

PROPERTIES: Occurs in colorless, transparent, tabular, rhombic crystals, becoming gray or grayish black on exposure to light or in the presence of organic matter; odorless, and having a bitter, caustic, and strongly metallic taste. Soluble in 0.4 part of water and in 30 parts of alcohol. An aqueous solution is clear, colorless, and neutral to litmus paper.

PREPARATION: It is made by dissolving silver in nitric acid with the aid of heat, $3Ag+4HNO_3=3AgNO_3+2H_2O+NO$.

ACTION AND USES: Solutions of silver nitrate should be made with distilled water. Weak solutions are astringent and antiseptic to mucous membranes and strong solutions are caustic. The mucous membrane should always be cleaned before applying solutions of silver nitrate. A 1 per cent solution is instilled into the eyes of the newborn immediately after delivery to prevent gonorrhœal conjunctivitis. The action of silver nitrate can be immediately stopped by the application of sodium chloride (salt) solution and this is often done when it is desired to limit the action of local application to the eye or throat. Silver nitrate forms on tissue a dense film of coagulated albumin. This film prevents deeper action of the silver nitrate. The film is at first white but soon becomes black due to the reduction of the silver. A 4 per cent solution is used for application to the mucous membrane of the throat, mouth or nose.

Average dose: 0.01 Gm. or 1/6 grain.

Argenti Nitras Induratus, Toughened Silver Nitrate (Lunar Caustic), U. S. P.—Toughened Silver Nitrate contains not less than 94.5 per cent of $AgNO_3$. Preserve it in glass-stoppered bottles, in a cool place and protected from light.

DESCRIPTION: White, crystalline masses generally molded as pencils or cones. It breaks with a fibrous fracture. On exposure to light in the presence of organic matter Toughened Silver Nitrate becomes gray or grayish-black. It contains about 5 per cent silver chloride.

ACTION AND USES: It is used as a caustic on excessive granulations, chancroids, and ulcers. The mode of application consists of dipping the stick into distilled water and applying to the part according to the degree of action desired.

Argentum Proteinicum Forte, Strong Protein Silver (Strong Silver Protein), U. S. P.—A compound of silver and protein, containing not less than 7.5 per cent and not more than 8.5 per cent of Ag. Preserve it in well-closed containers and protected from light.

CAUTION: *Solutions of Strong Protein Silver should be freshly prepared with distilled water and should be dispensed in amber-colored bottles.*

DESCRIPTION: A brown, odorless powder, usually somewhat hygroscopic. It is freely soluble in water, but almost insoluble in alcohol. Sodium chloride does not precipitate silver from a solution of silver protein. With mercuric chloride test solution a white precipitate is formed and the supernatant liquid becomes colorless or nearly so.

ACTION AND USES: It is used in one-half of 1 per cent aqueous solution for injection into the urethra for the prevention and treatment of gonococcus infection of the urethra. The solution should be made in small quantities as needed. It is more irritating than Mild Silver Protein. Linen stains may be removed with 1–1,000 bichloride of mercury solution.

Argentum Proteinicum Mite, Mild Protein Silver (Mild Silver Protein), U. S. P.—Silver rendered colloidal by the presence of, or combination with, protein. It contains not less than 19 per cent and not more than 25 per cent of Ag.

CAUTION: *Solutions of Mild Protein Silver should be freshly prepared with distilled water and should be dispensed in amber-colored bottles.*

Preserve it in well-closed containers and protected from light.

DESCRIPTION: Dark brown or almost black shining scales or granules. It is odorless, and is frequently hygroscopic. It is freely soluble in water, but almost insoluble in alcohol. With sodium chloride solution, a solution of silver protein does not precipitate silver. With mercuric chloride test solution a white precipitate is formed and the supernatant liquid becomes colorless, or nearly so. Penis syringes should not be kept in a bichloride of mercury solution if they are to be used with either the strong or the mild silver protein.

ACTION AND USES: In the preparation of solutions of silver protein they are likely to gum together if water is poured upon them; they then dissolve very slowly, but solutions can be made quickly if they are sprinkled upon the water and immediately shaken for a minute or two. Solution is also aided by wetting them first with glycerin. It is nonirritating and soothing, but less active as an antiseptic than Strong Protein Silver. It is used in the treatment of inflamed sensitive mucous membranes of the urethra, eye, and throat. It is usually used in strengths of from 5 to 20 per cent in distilled water.

Copper compounds.

Cupri Sulfas, Copper Sulfate, (Blue Vitriol, Bluestone, Cupric Sulfate), $CuSO_4.5H_2O$, U. S. P.—It contains not less than 63 per cent nor more than 66.8 per cent of $CuSO_4$, corresponding to not less than 98.5 per cent of the hydrated salt ($CuSO_4+5H_2O$). Preserve it in well-closed containers.

PROPERTIES: It occurs as deep blue triclinic crystals, or as blue crystalline granules or power, having a nauseous, metallic taste; slowly efflorescent in dry air; soluble in 3 parts of water, 500 parts of alcohol, and 2.8 parts of glycerin. Its aqueous solution is acid to litmus.

PREPARATION: It is made by the action of sulfuric acid on copper. $Cu+2H_2SO_4=CuSO_4+SO_2+2H_2O$.

ACTION AND USES: Internally it is used as an emetic, an astringent, or tonic, and an antidote for phosphorus poisoning. In small doses it acts as an astringent, while in large doses it is an irritant and is nauseating. It is astringent and antiseptic even in a strength of 1 to 1,000. Its aqueous solution is very destructive to the lower forms of plant life (fungi). It is used in the preparation of Fehling's solution, a reagent used in testing for the presence of sugar in urine.

Average dose: 0.3 Gm. or 5 grains as an emetic; 0.01 to 0.03 Gm. or 1/5 to 1/2 grain as an astringent or tonic.

ORGANIC MATERIA MEDICA

In the study of inorganic materia medica it was found that most of the substances were obtained or derived from the mineral kingdom. In the study of organic materia medica it will be found that most of the substances are obtained or derived from the vegetable and animal kingdoms or are made synthetically. *Organic materia medica is the study of those compounds of carbon that are used in medicine.* In this chapter only those used in the Medical Department of the Navy are discussed. The substances have been divided into groups, as far as practicable, according to chemical classification.

Hydrocarbons.

Hydrocarbons are chemical compounds formed by the union of the elements hydrogen and carbon. There are hundreds of these compounds, but only a few are on the Supply Table. For the general properties of the hydrocarbons refer to the chapter on Chemistry.

Petrolatum, Petrolatum (Petroleum Jelly), U. S. P.—A purified mixture of semisolid hydrocarbons, obtained from petroleum.

PROPERTIES: It is an unctuous mass; yellowish to light amber in color; transparent in thin layers; free from odor and taste. It is insoluble in water, almost insoluble in alcohol, soluble in ether, chloroform, oil of turpentine, benzine, or in most fixed or volatile oils. It melts between 38° and 54° C. Chemically it is very stable and does not turn rancid like vegetable oils and animal fats. It remains unchanged when brought in contact with strong acids or alkalies.

PREPARATION: It is an intermediate product in the distillation of crude petroleum. It comprises a part of the residue left after distillation of the lighter substances.

ACTION AND USES: It is used as a bland, neutral, protective dressing, and as a base for ointments. The absorption and rapidity of action of drugs is retarded when incorporated with petrolatum; therefore it should not be used alone as an ointment base when absorption of a drug is desired. Given internally it is not absorbed from the intestinal tract; it acts as a lubricant and may be used in gastrointestinal irritation. White Petrolatum, U. S. P., is petrolatum that has been decolorized.

Petrolatum Liquidum, Liquid Petrolatum (Mineral Oil, Liquid Paraffin), U. S. P.—A mixture of liquid hydrocarbons obtained from petroleum. Preserve it in well-closed containers, protected from light. The U. S. P. recognizes two kinds of liquid petrolatum—*heavy liquid petrolatum* having a viscosity of not more than 0.381, which is intended to be used as a laxative, and *light liquid petrolatum* having a viscosity of not more than 0.370 and intended to be used as a solvent in making sprays.

PROPERTIES: Both varieties are colorless, transparent, oily liquids; free or nearly free from fluorescence, odorless and tasteless when cold; insoluble in water or alcohol, but soluble in ether, chloroform, benzine, and volatile oils.

It is miscible with most fixed oils and dissolves menthol, camphor, and similar substances.

PREPARATION: It is made from crude petroleum after removal of the lighter hydrocarbons (gasoline, kerosene, etc.) by distilling the residue between 330° and 390° C. It should be noted that the definition does not state that it is a mixture of hydrocarbons of any particular chemical series.

ACTION AND USES: Largely used in the treatment of constipation. Its action is mechanical, as it is not absorbed. It simply oils the entire intestinal tract and facilitates the passage of the fæcal mass. Used as a vehicle in the preparation of the oil sprays for the nose and throat and in the preparation of petroxolins (N. F. preparations).

Average dose: 15 cc or 4 fluidrams.

Paraffinum, Paraffin, U. S. P.—A purified mixture of solid hydrocarbons obtained from petroleum.

PROPERTIES: It is a colorless or white, more or less translucent mass, crystalline when separating from solution, without odor or taste, and slightly greasy to the touch. It is insoluble in water or alcohol, but freely soluble in ether, benzene, volatile oils, and most fixed oils when warm. Like petrolatum, it is chemically inactive and resistant to the action of other chemicals. It melts between 50° and 57° C.

PREPARATION: It is made by distilling the residuum obtained from the refining of crude petroleum and collecting and purifying the distillate.

ACTION AND USES: It is used in ointments in hot climates to raise their melting points; in making paraffin paper; for sealing bottles; in making candles; and in the preparation of paraffin-wax compounds. Paraffin Dressing, N. F., is used as a surgical dressing for burns.

Ichthammol (Ammonium Ichthosulfonate), N. F.—It is obtained by the destructive distillation of certain bituminous schists, sulfonating the distillate, and neutralizing the product with ammonia. Ichthammol yields not less than 2.5 per cent of ammonia, not more than 8 per cent of ammonium sulfate, and not less than 10 per cent of total sulfur.

PROPERTIES: It is a reddish-brown to brownish-black, viscous fluid with a strong, characteristic, empyreumatic odor. It is soluble in water and in glycerin, and is miscible with fixed oils and fats. It is partly soluble in alcohol or ether, and entirely soluble in a mixture of equal volumes of alcohol and ether.

ACTION AND USES: It is weakly antiseptic and emollient. It is used in ointments (Ointment of Ichthammol, N. F.) for the local treatment of furunculosis (boils). It is not given internally.

Halogen derivatives of hydrocarbons.

Halogen derivatives of hydrocarbons are compounds formed by substituting one or more halogen atoms (chlorine, bromine, fluorine, or iodine) for a corresponding number of hydrogen atoms in hydrocarbon compounds. The substitution may be done directly or indirectly. (*See* chapter on Chemistry.) The simplest hydrocarbon known is methane, CH_4, which contains four hydrogen atoms united to one carbon atom. Substituting three chlorine atoms for three of the hydrogen atoms in methane produces a compound known as trichlormethane, $CHCl_3$ (chloroform); if the substitution is with three iodine atoms, a compound known as triiodomethane, CHI_3 (iodoform) results; if one chlorine atom is substituted for one hydrogen atom in ethane (C_2H_6), a compound known as monochlorethane, C_2H_5Cl (ethyl chloride), is formed, etc.

Chloroformum, Chloroform, $CHCl_3$, U. S. P.—A liquid consisting of not less than 99 per cent nor more than 99.5 per cent by weight of $CHCl_3$ and the

remainder consisting of alcohol. Preserve it in well-stoppered bottles in a cool place protected from light. CAUTION: *Care should be used in vaporizing chloroform in the presence of a naked flame, as noxious gases are produced. Chloroform for anæsthesia must be preserved in glass bottles.*

PROPERTIES: A clear, colorless, mobile liquid, of a characteristic, ethereal odor and burning, sweet taste. Soluble in 210 parts of water; miscible with alcohol, ether, benzene, petroleum, benzine, or with fixed or volatile oils. Specific gravity, 1.474 to 1.478 at 25° C. It is volatile at a low temperature and boils at about 61° C. It is not inflammable, but its heated vapor burns with a green flame. Chloroform is decomposed when exposed to light and air, liberating chlorine, hydrochloric acid, phosgene, and other compounds. The presence of a small amount of alcohol tends to prevent this decomposition. Chloroform that has been exposed to light and air should not be used for anæsthesia.

PREPARATION: It is usually made by the action of chlorinated lime on acetone.

ACTION AND USES: Used in surgery as a general anæsthetic by inhalation; internally as a carminative and sedative; externally as a rubefacient and vesicant. It is used in the preparation of Chloroform Water, U. S. P., Chloroform Liniment, U. S. P., and Spirit of Chloroform, U. S. P.

Average dose: 0.3 cc or 5 minims.

Iodoformum, Iodoform, CHI_3, U. S. P.—Triiodomethane. Preserve it in well-closed containers, in a cool place and protected from light.

PROPERTIES: It occurs as a fine, lemon-yellow powder or in lustrous crystals of the hexagonal system having a peculiar, very penetrating and persistent odor and an unpleasant, slightly sweetish taste suggestive of iodine. It is nearly insoluble in water, but soluble in 60 parts of alcohol, 80 parts of glycerin, 10 parts of chloroform, 7.5 parts of ether, 2.8 parts of carbon disulfide and in 34 parts of olive oil. The unpleasant odor may be partially disguised in ointments by adding 5 drops of oil of peppermint to the ounce. The odor of iodoform on utensils may be partially removed by wiping them off with oil of turpentine, followed by washing with soap and water.

PREPARATION: Made by the action of iodine upon alcohol or acetone in the presence of an alkali or alkali carbonate.

ACTION AND USES: It is used externally in the form of dusting powder, ointment, or iodoform gauze as an antiseptic and stimulating dressing to wounds and ulcers. Its antiseptic properties are due to iodine, of which it contains over 96 per cent by weight. Iodoform gauze may be made by saturating surgical gauze with a 5 per cent solution of iodoform in ether and allowing to dry.

Average dose: 0.25 Gm. or 4 grains. (Rarely given internally.)

Æthylis Chloridum, Ethyl Chloride, CH_3CH_2Cl, U. S. P.—Monochlorethane. Preserve it in hermetically sealed containers in a cool place, remote from fire and protected from light.

PROPERTIES: At low temperatures or under pressure ethyl chloride is a colorless, mobile, very volatile liquid, having a characteristic ethereal odor and a burning taste. It boils between 12° and 13° C. It burns with a smoky, greenish flame with the production of hydrochloric acid. When liberated at room temperature from its sealed container it vaporizes at once. CAUTION: *The gas is very inflammable and must not be used in proximity to fire.*

PREPARATION: Ethyl chloride may be made by the action of hydrochloric acid upon alcohol: $C_2H_5OH + HCl = C_2H_5Cl + H_2O$.

ACTION AND USES: When inhaled it produces general anæsthesia promptly and may be used for operations that require only a few minutes. Sprayed on a part of the body it produces refrigeration and is used as a local anæsthetic in minor operations.

Carbonei Tetrachloridum, Carbon Tetrachloride, (Tetrachlormethane), CCl_4, U. S. P.

PROPERTIES: A clear, colorless, mobile liquid. It has a characteristic, ethereal odor, resembling that of chloroform. It is not inflammable. It is slowly decomposed by light, and by various metals if moisture is present. It is almost insoluble in water. It is miscible with alcohol, chloroform, ether, benzene, petroleum benzine, and dissolves most of the fixed and volatile oils. It has a high specific gravity and a low boiling point. It should be preserved in well-closed containers and protected from light.

PREPARATION: It is made by the action of chlorine upon carbon disulfide under the influence of a catalytic agent.

ACTION AND USES: It has narcotic and anæsthetic properties somewhat similar to those of chloroform. It is given internally as a vermifuge in the treatment of hookworm disease, and also removes some other intestinal worms. Its administration should be followed in 3 hours by a purgative dose of magnesium sulfate. It is used as a fire extinguisher (pyrene). When used as a fire extinguisher, poisonous gases—phosgene and hydrochloric acid—are formed by the heat, and unless these gases are blown away from the man using the fire extinguisher poisoning is likely to occur. It should not be used in unventilated spaces or closed compartments.

Average dose: 2.5 cc or 40 minims. (This is a single dose for an adult as an anthelmintic and is not to be repeated under 3 weeks.)

Chloramina-T, Chloramine-T, U. S. P.—Sodium paratoluenesulfonchloramide containing the equivalent of not less than 11.5 per cent and not more than 13 per cent of active chlorine (Cl). Preserve it in well-closed containers protected from light.

PROPERTIES: A white or faintly yellow, crystalline powder, having a slight odor of chlorine. It slowly decomposes on exposure to air, losing chlorine. One gram is soluble in 7 cc of water. It is soluble in alcohol but the solution decomposes on standing.

ACTION AND USES: It is used in 0.1 to 4 per cent aqueous solution as an antiseptic wound dressing. It was first used during the World War as a substitute for Dakin's Solution (Solution of Sodium Hypochlorite). It has the advantage over Dakin's Solution of greater stability, is easier to prepare, and produces less irritation. It lacks the solvent action of the alkaline hypochlorites.

Alcohols.

Alcohols are compounds formed by the replacement of one of more hydrogen atoms of a paraffin hydrocarbon with an equal number of hydroxyl (OH) groups. If one hydroxyl group is substituted for one hydrogen atom in methane (CH_4) an alcohol known as methanol (CH_3OH) (methyl or wood alcohol) results; if one hydroxyl group is substituted for one hydrogen atom in ethane (C_2H_6) an alcohol known as ethanol (C_2H_5OH) (ethyl or grain alcohol) is obtained; if three hydroxyl groups are substituted for three hydrogen atoms in propane (C_3H_8) an alcohol known as glycerol ($C_3H_5(OH)_3$) (glyceric alcohol or glycerin) occurs. Alcohols are designated monatomic, diatomic, triatomic, etc., accordingly as they contain one, two, three, etc., hydroxyl (OH) groups. Alcohols are related closely to hydroxides or bases in inorganic chemistry, and sometimes they are referred to as organic hydroxides. When acted upon by an acid they form a salt (ester) and water which is analogous to the reaction that takes place when an acid acts on a base (hydroxide). They have a neutral reaction to litmus if pure.

Alcohol, Alcohol (Ethanol, Ethyl Alcohol), C_2H_5OH, U. S. P.—A mixture of alcohol and water containing not less than 92.3 per cent by weight or 94.9 per

cent by volume at 15.56° C., of C_2H_5OH. Preserve it in well-closed containers in a cool place, remote from fire.

PROPERTIES: It is a transparent, colorless, mobile, and volatile liquid, having a slight characteristic odor and a burning taste. Miscible in all proportions with water, ether, and chloroform. Specific gravity not above 0.816 at 15.56° C. (the United States Government standard temperature for alcohol). It is easily volatilized at low temperature and boils at 78° C. It is inflammable and burns with a pale blue, smokeless flame.

PREPARATION: Alcohol is made by the fermentation of starch contained in grain. In making U. S. P. alcohol, rectified spirit is macerated with dehydrating agents (quicklime) to remove water, and then is distilled.

ACTION AND USES: Alcohol is used as a diffusible stimulant and hypnotic. Large doses cause intoxication by depression and, finally, paralysis of the central nervous system. Externally alcohol is used as a refrigerant in giving baths and alcohol rubs. It is a valuable bacteriostatic and is used extensively in surgery in 70 per cent strength. In pharmacy it is used as a solvent in making spirits, tinctures, elixirs, and fluid extracts.

Average dose: 10 cc or 2.5 fluidrams.

Alcohol Dilutum, Diluted Alcohol, U. S. P.—A liquid containing from 41 to 42 per cent by weight, or from 48.4 to 49.5 per cent by volume at 15.56° C. of C_2H_5OH. Preserve it in well-closed containers, in a cool place, remote from fire.

PREPARATION: It is made by mixing equal volumes of U. S. P. alcohol and distilled water. When 500 cc of alcohol and 500 cc of distilled water are mixed, instead of getting 1,000 cc of dilute alcohol only about 970 cc are obtained due to contraction in volume when these two liquids are mixed.

Alcohol Dehydratum, Dehydrated Alcohol, U. S. P.—A liquid commonly known as absolute alcohol and containing not less than 99 per cent by weight of C_2H_5OH. Preserve it in well-closed containers, in a cool place, remote from fire. If the stopper is removed, it should be securely replaced as soon as possible to prevent the absorption of water from the air.

PREPARATION: It is made from ordinary alcohol by redistillation after percolation through lime. There is still remaining 1 per cent of water, which is allowed.

ACTION AND USES: Absolute alcohol is used in microscopical work.

Alcohol Methylic, Methyl Alcohol (Wood Alcohol, Wood Naphtha, Wood Spirit, Carbinol, Methanol), CH_3OH.—Methyl alcohol is made by the destructive distillation of wood.

ACTION AND USES: It is used in microscopical work. It is an excellent solvent, but is unfit for use in pharmacy because it is a *dangerous poison, producing blindness and death.* It is used in denaturing ethyl alcohol and in making formaldehyde. CAUTION: *It should never be used internally.*

Spiritus Frumenti, Whisky, U. S. P.—An alcoholic liquid obtained by the distillation of the fermented mash of wholly or partly malted cereal grains, and containing, at 15.56° C., not less than 47 per cent and not more than 53 per cent, by volume, of C_2H_5OH. It must have been stored in charred wood containers for a period of not less than 4 years.

PROPERTIES: A light to deep amber-colored liquid, having a characteristic odor and taste, and an acid reaction.

ACTION AND USES: It is given internally as a diffusible stimulant. Diluted Alcohol may be used internally in the place of Whisky.

Glycerinum, Glycerin, (Glycerol), $C_3H_5(OH)_3$, U. S. P.—A liquid obtained by the hydrolysis of vegetable or animal fats, or fixed oils; purified by distillation.

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and containing not less than 95 per cent of the trihydric alcohol $C_3H_5(OH)_3$ or $CH_2OH.CHOH.CH_2OH$. Preserve it in well-closed containers.

PROPERTIES: It is a clear, colorless liquid, of a thick, syrupy consistency, having not more than a slight characteristic odor; sweet to the taste and producing a sense of warmth in the mouth; when it is exposed to the air it absorbs moisture. It is miscible with water or alcohol in all proportions; insoluble in chloroform, ether, benzene, petroleum benzine, and fixed or volatile oils.

PREPARATION: Glycerin is a by-product in the manufacture of soap. Whenever an alkali acts on a fixed oil or an animal fat a soap and glycerin are formed. The process is called saponification.

ACTION AND USES: It is extensively used in pharmacy as a solvent. It possesses the advantages of easily mixing with alcohol and water; is slightly antiseptic and preservative; has a sweet taste, and will dissolve many medicinal substances. It is used in making glycerin suppositories, glycerinated gelatin, and glycerites. It tends to keep substances from becoming hard.

Aldehydes and aldehyde derivatives.

The word "aldehyde" is derived from alcohol dehydrogenatum, meaning alcohol from which hydrogen has been extracted, and referring to the method of preparing aldehydes. If two atoms of hydrogen are extracted from methyl alcohol ($CH_3.OH-H_2=H.CHO$), formic aldehyde or formaldehyde is formed. The extraction of the hydrogen usually is accomplished by bringing some substance in contact with the alcohol that has a greater attraction for the hydrogen than has the carbon. Such a substance is oxygen, and the process of extracting the hydrogen is called oxidation; therefore it is said that formaldehyde is made by the oxidation of methyl alcohol. When an aldehyde is oxidized (this time the oxygen is added to the carbon instead of taking something from it), it is converted into an acid: ($2H.CHO+O_2=2H.COOH$); when acetic aldehyde is oxidized it is converted into acetic acid: ($2CH_3.CHO+O_2=2CH_3COOH$). The aldehyde group is CHO and is contained in all aldehydes.

Liquor Formaldehydi, Solution of Formaldehyde (Formalin), H.CHO, U. S. P.—An aqueous solution containing not less than 37 per cent by weight of H.CHO with varying amounts of methanol to prevent polymerization. Preserve it in a moderately warm place, protected from light.

PROPERTIES: It is a clear, colorless, or nearly colorless liquid having a pungent odor and a caustic taste; its vapor acts as an irritant upon mucous membranes. It is miscible with water or alcohol. On long standing, especially in the cold, Solution of Formaldehyde sometimes loses its transparency, the cloudiness being due to the separation of paraformaldehyde (polymerization). Chemically it is a reducing agent.

PREPARATION: It is made by the oxidation of methyl alcohol: $2CH_3.OH+O_2=2H.CHO+2H_2O$.

ACTION AND USES: It is a powerful antiseptic and disinfectant. It acts as a disinfectant in aqueous solution in strengths of from 1 to 2 per cent (per cent here refers to the amount of absolute formaldehyde, H.CHO). This strength may be used in the disinfection of the hands, linen, or surgical instruments having cutting edges. A 1 to 10 solution in alcohol is used for the preservation of tissue. A solution composed of 13.5 cc of formalin, 5 Gm. of borax, and sufficient water to make 100 cc is used as an embalming fluid. It is used as a room disinfectant with barium dioxide. Five hundred cc of formalin mixed with 250 Gm. of barium dioxide in a suitable container will generate sufficient

formaldehyde gas to disinfect 1,000 cubic feet of air space. Formaldehyde is one of the few true deodorants.

Methenamina, Methenamine (Hexamethylenetetramine). U. S. P.—A condensation product of ammonia and formaldehyde containing not less than 99 per cent of $(CH_2)_6N_4$. Preserve it in well-closed containers.

PROPERTIES: It occurs as colorless, lustrous, odorless crystals, or a white, crystalline powder; soluble in 1.5 parts of water and in 12.5 parts of alcohol. Its aqueous solution is alkaline to litmus.

PREPARATION: It is made by the action of ammonia on formaldehyde.

ACTION AND USES: It is a urinary antiseptic, its antiseptic action being due to the liberation of formaldehyde in the normally acid urine in the bladder. Unless the urine in the bladder is acid there will not be enough formaldehyde set free to do any good and it is therefore often given in conjunction with acid sodium phosphate which renders the urine acid and permits more formaldehyde to be liberated. It has produced hæmaturia and should be used cautiously.

Average dose: 0.25 Gm. or 4 grains.

Chloralis Hydras, Chloral Hydrate (Chloral), U. S. P.—A compound of trichloracetaldehyde or chloral, with the elements of one molecule of water. It contains not less than 99.5 per cent of $C_2H_3O_2Cl_3$. Preserve it in tightly stoppered bottles, in a cool place, protected from light.

PROPERTIES: It occurs in colorless, transparent crystals having an aromatic, penetrating, and slightly acrid odor, and a bitterish, caustic taste. It is slowly volatilized when exposed to the air. It is soluble in 0.25 part of water, 1.3 parts of alcohol, 2 parts of chloroform, and 1.5 parts of ether; very soluble in olive oil, freely soluble in oil of turpentine. It is decomposed by alkalies, liberating chloroform.

PREPARATION: It is made by passing chlorine gas through absolute alcohol, resulting first in the conversion of alcohol to acetaldehyde, and then the acetaldehyde is converted into trichloracetaldehyde (chloral).

$$(1)\quad CH_3CH_2OH+Cl_2=CH_3CHO+2HCl$$
$$(2)\quad CH_3CHO+3Cl_2=CCl_3CHO+3HCl$$

ACTION AND USES: It is a powerful nerve sedative and hypnotic and is used in insomnia, hysteria, the various forms of insanity, and delirium tremens. It usually is given with bromides. It is used to cause muscular relaxation in tetanus and strychnine poisoning, when large doses are necessary. It is a habit-forming drug and should be used cautiously. It is one of the 11 drugs mentioned in the Federal Pure Food and Drugs Act and the amount contained in any preparation must appear on the label when it enters interstate commerce.

Average dose: 0.5 Gm. or 8 grains.

Ethers.

Ethers may be defined as oxides of hydrocarbon radicals. There are simple ethers and mixed ethers. Simple ethers are formed by the union of two like hydrocarbon radicals with one oxgen atom; $(C_2H_5)_2O$ is diethyl ether (ether); compound ethers are formed by the union of two unlike hydrocarbon radicals with one oxygen atom, $(CH_3)(C_2H_5)O$ is methyl-ethyl ether. Ethers in organic chemistry are analogous to oxides in inorganic chemistry. The term very often is applied erroneously to esters. It should be understood clearly that ethers and esters are two different and distinct classes of organic compounds. Ethers are organic oxides, while esters are organic salts. (*See* chapter on Chemistry.)

Æther, Ether (Sulfuric Ether), $(C_2H_5)_2O$, U. S. P.—A liquid containing not less than 96 per cent nor more than 98 per cent of ethyl oxide $(C_2H_5)_2O$, the re-

mainder consisting of alcohol and water. Preserve it in partially filled, well-closed, light-proof containers, in a cool place, remote from fire. When ether is to be used for anæsthesia it is to be dispensed only in small, well-closed containers and is not to be used for this purpose if the container has been opened longer than 24 hours.

PROPERTIES: Ether is a transparent, colorless, mobile liquid, having a characteristic odor and a burning sweetish taste. It is soluble in 12 parts of water and is miscible with alcohol, chloroform, petroleum benzine, benzene, or fixed and volatile oils. It boils at about 35° C. *It is highly volatile and inflammable. Its vapor when mixed with air and ignited may explode violently.* It is slowly oxidized by the action of air, moisture, and daylight.

PREPARATION: It is made by the action of sulfuric acid on alcohol.

$$(1) \qquad C_2H_5OH+H_2SO_4=C_2H_5HSO_4+H_2O$$
$$(2) \qquad C_2H_5HSO_4+C_2H_5OH=(C_2H_5)_2O+H_2SO_4$$

ACTION AND USES: It is administered by inhalation to produce general anæsthesia. In the administration of ether great care should be exercised to see that a flame is not brought near the vapor. In pharmacy it is used as a solvent in the preparation of oleoresins and in the assay of alkaloids. Given internally it acts as a cardiac stimulant, carminative, and antispasmodic. Solvent Ether was admitted to the Eleventh Revision of the U. S. P. under the name "Ethyl Oxide", and may be purchased in larger containers at a lower cost than "Anæsthetic Ether." The tests for aldehydes and peroxides in Ethyl Oxide are less rigid than for Æther, U. S. P.

Phenols and phenol derivatives.

Phenols may be defined as compounds formed by the substitution of one or more hydroxyl (OH) groups for a corresponding number of hydrogen atoms that are connected directly with carbon atoms in the benzene nucleus (C_6H_6). A phenol formed by substituting one hydroxyl (OH) group for one hydrogen atom in benzene (C_6H_6) is known as a monatomic phenol (C_6H_5OH), ordinary phenol; the substitution of two hydroxyls for two hydrogens would give a diatomic phenol ($C_6H_4(OH)_2$), resorcinol; the substitution of three hydroxyls for three hydrogens would give a triatomic phenol ($C_6H_3(OH)_3$), pyrogallol. The substitution of three nitro groups for three of the hydrogen atoms in phenol (C_6H_5OH) gives a compound known as trinitro-phenol ($C_6H_2OH(NO_2)_3$, or picric acid. It should be understood clearly that phenols are a distinct class of compounds. The term "phenol" is the name given to the most important member in this class, just as "alcohol" is the name applied to the most important member in the class of alcohols and the term "ether" to the most important member of the class of ethers.

Some of the phenols are liquids and some are solids; they all have a characteristic odor; they act like weak acids, forming salts with strong alkalies, but they do not decompose carbonates, and their reaction to litmus is neutral or only faintly acid. They are nearly all very poisonous; most of them are disinfectants or antiseptics; are soluble in alcohol and sparingly soluble in water. Some are found in the vegetable kingdom (thymol) and some are formed when complex carbon compounds are subjected to destructive distillation; wood tar and coal tar, the residues resulting from the destructive distillation of wood and coal, contain phenols (phenol and cresol). *A general measure against the caustic action of phenols (externally) is ethyl alcohol (grain alcohol), which dilutes the phenol, thereby weakening its action as well as making it easier to remove. Wash off the phenol thoroughly with alcohol and then apply cotton-seed oil dressings. Oils prevent penetration of*

phenol into the tissues and absorb phenol from the tissues. For the treatment of poisoning by phenol when it has been swallowed see section on Toxicology.

Phenol, Phenol (Carbolic Acid), C_6H_5OH, U. S. P.—It is obtained from coal tar or made synthetically. It contains not less than 98 per cent of C_6H_5OH. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs as colorless, interlaced or separate needle-shaped crystals, or as a white, crystalline mass, sometimes acquiring a red tint, having a characteristic, somewhat aromatic odor. When undiluted it cauterizes and whitens the skin and mucous membrane. It is soluble in 15 parts of water; very soluble in alcohol, glycerin, chloroform, ether, and in fixed or volatile oils. When heated it melts, forming a highly refractive liquid. It also is liquefied by the addition of about 8 per cent of water.

PREPARATION: It is obtained from coal tar by fractional distillation and subsequent purification. It also is made synthetically.

ACTION AND USES. *See* Liquefied Phenol.

Phenol Liquefactum, Liquefied Phenol (Liquefied Carbolic Acid), U. S. P.—A liquid containing not less than 88 per cent of C_6H_5OH and about 10 per cent of water. Preserve it in well-closed containers, protected from the light.

PROPERTIES: It is a colorless liquid, which may develop a red tint upon keeping, having a characteristic, somewhat aromatic odor. When undiluted it cauterizes the skin and mucous membrane. It is miscible with ether, alcohol, and glycerin. When it is diluted with an equal volume of glycerin the mixture is miscible with water.

PREPARATION: It is made by melting crystallized phenol on a water bath. It then is poured into a tared vessel and weighed, and to every 9 Gm. of phenol is added 1 Gm. (1 cc) of distilled water, mixed thoroughly.

ACTION AND USES: It is a valuable antiseptic and disinfectant. A 5 per cent solution may be used for the disinfection of the hands, soiled linen, stools, urine, bedpans, urinals, etc. In concentrated form it acts as a caustic and local anæsthetic. Applied in a tooth cavity on a small pellet of cotton that has first been touched to another piece of cotton to remove excess fluid, it relieves toothache. *If pure phenol is spilled on the skin or in the mouth, it should be washed off immediately with alcohol.* The concentrated phenol coagulates albumin, but its weaker aqueous solutions do not. Concentrated liquefied phenol is used for the disinfection of cutting-edged instruments which are damaged by boiling; after taking the instruments out of the phenol they are rinsed in alcohol to remove all the phenol. *When phenol is to be mixed with a fixed oil, liquid petrolatum, or petrolatum, use melted crystalline phenol instead of liquefied phenol, because the water in liquefied phenol is insoluble in these solvents.*

Average dose: 0.05 cc or 1 minim.

Cresol, Cresol (Tricresol), U. S. P.—A mixture of isomeric cresols, $C_6H_4.CH_3.OH$, obtained from coal tar. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs as a colorless or yellowish to brownish-yellow, highly refractive liquid, becoming darker or assuming a reddish tint with age and on exposure to light, and having a phenol-like, sometimes empyreumatic odor. It is soluble in 50 parts of water; miscible with alcohol, ether, glycerin, benzene, or petroleum benzine. It also is dissolved by solutions of the fixed alkali hydroxides and soap solutions.

PREPARATION: It is obtained from the phenol-distillates of coal tar.

ACTION AND USES: The action of cresol is similar to that of phenol except that it is stronger. It is a good disinfectant in the strength of 2 per cent solution for urinals, bedpans, stools, sputum cups, etc. It is used principally

in the form of Saponated Solution of Cresol, U. S. P. for disinfection of utensils, hands, and in obstetrical work, in strengths of from 1 to 3 per cent. The poisonous effects of cresol are similar to those of phenol and the treatment is the same as for phenol poisoning.

Liquor Cresolis Saponatus, Saponated Solution of Cresol (Compound Solution of Cresol), U. S. P.—Preserve it in well-closed containers. It contains 50 per cent cresol in linseed-oil soap.

PROPERTIES: It forms a clear solution with water. With water containing calcium or magnesium it forms a slightly cloudy solution due to the precipitation of insoluble soaps of these metals.

ACTION AND USES: It is twice as strong as phenol as a germicide. It is less caustic but equally as poisonous as phenol. A weak aqueous (1 per cent) solution is used as a vaginal douche. A 2 per cent aqueous solution may be used for disinfecting the hands. Instruments that cannot be boiled may be disinfected by using a 5 per cent aqueous solution. If accidentally swallowed, give an emetic followed by magnesium sulfate and demulcent drinks.

Trinitrophenol, Trinitrophenol (Picric Acid), ($C_6H_2OH(NO_2)_3$, U. S. P.—Preserve it in well-stoppered bottles, in a cool place, remote from fire. Caution: For safety in transportation it usually is mixed with about 20 per cent of water.

PROPERTIES: It occurs in pale yellow, rhombic prisms or scales; odorless, and having an intensely bitter taste. CAUTION: *It explodes when heated rapidly and when subjected to percussion.* It is soluble in 78 parts of water, 12 parts of alcohol, 35 parts of chloroform, 65 parts of ether, and in 10 parts of benzene. Its aqueous solution is acid to litmus.

PREPARATION: It is made by the action of nitric acid on phenol, resulting in the substitution of the nitro groups (NO_2) for three hydrogen atoms in phenol.

ACTION AND USES: It is astringent and antiseptic. Its saturated aqueous solution is used mainly in the treatment of burns. Gauze saturated with the solution is applied to the burned area. A 5 per cent alcoholic solution is used (like tincture of iodine) in the first-aid treatment of wounds as a disinfectant. Picric acid solution should not be used in the treatment of burns covering a large area of the body as poisoning may occur.

Resorcinol, Resorcinol (Resorcin), ($C_6H_4(OH)_2$), U. S. P.—Meta-dihydroxybenzene. It contains not less than 99.5 per cent of $C_6H_4(OH)_2$. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs as colorless, or nearly colorless, needle-shaped crystals, or as a powder, having a faint peculiar odor and a sweetish, followed by bitter taste. It acquires a pink tint on exposure to air and light. It is soluble in 0.9 parts of water, 0.9 parts of alcohol, freely soluble in glycerin or ether, slightly soluble in chloroform.

ACTIONS AND USES: It is antiseptic and antizymotic. It seldom is given internally. It is used in the form of an aqueous solution, and an ointment in the treatment of subacute and chronic skin diseases. The action after absorption is similar to that of phenol.

AVERAGE DOSE: 0.125 Gm. or 2 grains. (Rarely given internally.)

Creosotum, Creosote (Creasote), U. S. P.—A mixture of phenols obtained from wood tar. Preserve it in tightly-stoppered bottles, in a cool place and protected from light.

PROPERTIES: It is an almost colorless or yellowish, highly refractive, oily liquid, having a penetrating smoky odor, and a burning caustic taste; it does not readily become brown on exposure to light. It is slightly soluble in water, but is miscible with alcohol, ether, and fixed or volatile oils. It is inflammable.

ACTION AND USES: It is given internally as an antiemetic, an expectorant, and an intestinal antiseptic. The poisonous symptoms are like those of phenol and the treatment is the same. Locally it acts as an anæsthetic and antiseptic which makes it suitable for use in dental practice to stop toothache.

Average dose: 0.25 cc or 4 minims. When given freely it should be administered in emulsion or dissolved in milk in order to overcome its irritating local effect.

Creosoti Carbonas, Creosote Carbonate (Creosotal), U. S. P.—A mixture of the carbonates of various constituents of creosote.

PROPERTIES: It is a clear, colorless or yellowish, viscid liquid, odorless and tasteless, or having a slight odor of creosote. It is insoluble in water and freely soluble in alcohol and fixed oils.

ACTION AND USES: Being less irritating it is a good substitute for creosote internally. It is an expectorant.

Average dose: 1 Gm. or 15 grains.

Guaiacol, Guaiacol, U. S. P.—A liquid consisting principally of the monomethylether ($C_6H_4(OH)(OCH_3)$) of ortho-dihydroxybenzene obtained from wood-tar creosote, or a solid, consisting almost entirely of $C_6H_4(OH)(OCH_3)$, usually prepared synthetically.

PROPERTIES: It is a colorless or yellowish, strongly refractive liquid or a crystalline solid having an agreeable aromatic odor. It is soluble in 60 to 70 parts of water, 1 part of glycerin, and is miscible with alcohol, chloroform, ether, and glacial acetic acid. Solid guaiacol melts at about 28° C.

PREPARATION: It is made by the fractional distillation of wood-tar creosote. It also is made synthetically.

ACTION AND USES: It is used externally as an antipyretic by applying locally on the skin; 1 to 3 cc painted on the chest, thigh, or abdomen of a fever patient will cause a fall of several degrees in the temperature of the body in an hour followed by excessive sweating and depression. It produces partial local anæsthesia when applied externally and sometimes is used for superficial neuralgias. It is used internally as an expectorant in bronchitis and tuberculosis.

Average dose: 0.5 cc or 8 minims.

Acetophenetidinum, Acetophenetidin (Phenacetin), U. S. P.—The monoacetyl derivative ($C_6H_4(OC_2H_5).NH.CH_3CO$) of para-aminophenetol.

PROPERTIES: It occurs as a white crystalline powder, odorless, and having a bitter taste. It is soluble in 1,310 parts of water and 15 parts of alcohol.

ACTION AND USES: It is antipyretic, analgesic, and a cardiac depressant. It is used extensively as a headache remedy.

Average dose: 0.3 Gm. or 5 grains.

Organic acids and their esters.

Organic acids are compounds formed by the union of a hydrocarbon radical with a carboxyl group (COOH). They also are called carboxylic acids. They are not made by directly connecting the carboxyl group to a hydrocarbon radical but by the oxidation of an alcohol to an aldehyde, and further oxidation of the aldehyde to an organic acid. The reactions taking place in the formation of acetic acid from ethyl alcohol may be expressed as follows: $2C_2H_5.OH+O_2=2CH_3.COH+2H_2O$; then, $2CH_3.COH+O_2=2CH_3COOH$. If the acid contains only one carboxyl group (COOH) it is a monobasic acid; if it contains two, it is a dibasic acid; if it contains three, it is tribasic, etc. The only hydrogen that is replaceable by a metal or basic radical in an organic acid is the hydrogen in the carboxyl group.

They possess the general properties of inorganic acids; they are sour to the taste, usually soluble in water, and have a strong acid reaction to litmus.

Some are liquids and some are solids. They are not as corrosive as the inorganic acids, some being very mild in their acid properties. They decompose carbonates and combine with metals and basic radicals to form salts.

Esters are compounds formed by the union of an organic and inorganic acid with a basic hydrocarbon radical. Erroneously they sometimes are called ethers. Examples of esters are ethyl acetate, ethyl chloride, phenyl salicylate, methyl salicylate, ethyl sulfate, etc. They frequently are called organic salts.

Acidum Aceticum Glaciale, Glacial Acetic Acid, $CH_3.COOH$, U. S. P.—A liquid containing not less than 99 per cent of $CH_3.COOH$. Preserve it in glass-stoppered bottles.

PROPERTIES: It is a clear, colorless liquid with a strong, vinegar-like, pungent odor and an acid taste. It is miscible with water or alcohol.

PREPARATION: It is one of the products resulting from the destructive distillation of wood. It may be made by oxidation of alcohol.

ACTION AND USES: It is a very energetic acid and acts as a caustic. It is used principally in the preparations of the weaker acids (acetic acid, U. S. P., 36 to 37 per cent, and diluted acetic acid, U. S. P., 5.7 to 6.3 per cent). It is used in the preparation of salts of acetic acid (acetates). When dropped upon the skin or mucous membranes it forms blisters and erodes the tissues beneath. It should be washed off the skin quickly with running water or soda solution. If swallowed accidentally give magnesium oxide mixed with water.

Average dose: The 99 per cent acid is not given internally. The dose of the diluted acid is 2 cc or 30 minims.

Acidum Benzoicum, Benzoic Acid, U.S.P.—It contains not less than 99.3 per cent of $C_6H_5.COOH$. It is found naturally in benzoin, balsam of tolu, balsam of Peru, storax, and other resinous substances from which it may be obtained by sublimation, but most of it is now produced synthetically. Preserve it in well-closed containers, in a cool place and protected from light.

PROPERTIES: Colorless crystals, as scales or needles. It is odorless or may have a slight odor of benzaldehyde or benzoin. It is somewhat volatile when warmed. One gram is soluble in 275 cc of water, 2.3 cc of alcohol, and 3 cc of ether. It is soluble in fixed and in volatile oils.

ACTION AND USES: In high dilutions it inhibits the growth of many organisms and in stronger solutions it is actively germicidal. It is sometimes used in mouth washes and is used in Whitfield's Ointment with salycilic acid for ringworm infections. It is stimulant, expectorant, and irritant to the mucous membranes. Benzoic acid and its salts, the benzoates, are used as food preservatives.

Average dose: 1 Gm. or 15 grains administered in thick mucilage or syrup.

Acidum Citricum, Citric Acid, U.S.P.—A tribasic organic acid usually obtained from the juice of limes or lemons. It contains not less than 99.5 per cent of $C_3H_4(OH)(COOH)_3 + H_2O$. Preserve it in well-closed containers.

PROPERTIES: It occurs as colorless, translucent crystals or as a white crystalline powder, odorless and having an acid taste, and is efflorescent in dry air. It is soluble in 0.5 part of water and 1.8 parts of alcohol.

ACTION AND USES: It is used in the preparation of citrates (solution of magnesium citrate, U. S. P.) and in the preparation of effervescent salts. It may be used as a substitute for lemon juice.

Acidum Salicylicum, Salicylic Acid, U. S. P.—Orthohydroxybenzoic acid. It exists naturally in combination in various plants but generally is prepared synthetically. It contains, when dried at 100° C. for 2 hours, not less than 99.5 per cent of $C_6H_4(OH)COOH$. Preserve it in well-closed containers, in a cool place, protected from light.

PROPERTIES: It occurs as colorless crystals, usually in fine needles, or a fluffy, white crystalline powder having a sweetish, afterwards acrid, taste. Synthetic salicylic acid is white and odorless; when prepared from methyl salicylate it may have a slight yellow tint and a slight gaultheria-like odor. It is soluble in 460 parts of water, 2.7 parts of alcohol, and 3 parts of ether.

ACTION AND USES: Used as an antipyretic and antirheumatic. It is used principally in the preparation of the salicylates (phenyl salicylate, U. S. P., sodium salicylate, U. S. P., and acetylsalicylic acid) which are preferred for internal use. It is used externally for the treatment of skin diseases in the form of ointment, alcoholic solution, and dusting powder. It is used in skin diseases for its antiseptic effect and also its power of softening the horny, hard layer of the skin. It is contained in many corn collodions.

Average dose: 0.5 Gm. or 8 grains.

Acidum Acetylsalicylicum, Acetylsalicylic Acid (Aspirin), U. S. P.—The acetyl derivative, ($C_6H_4.OCH_3CO.COOH$) of salicylic acid. Preserve it in well-closed containers.

PROPERTIES: It is a white crystalline powder or colorless crystals, odorless, and stable in dry air. It is sparingly soluble in water and freely soluble in alcohol. In moist air gradually hydrolizes into acetic and salicylic acids. It is decomposed by alkalies.

ACTION AND USES: It is used extensively as an antipyretic and antirheumatic. It is an excellent headache remedy. It must be used with caution because some individuals are easily poisoned by it, due probably to an idiosyncrasy. It should not be dispensed in solution because its aqueous solution slowly decomposes on standing.

Average dose: 0.3 Gm. or 5 grains.

Phenylis Salicylas, Phenyl Salicylate (Salol), U. S. P.—The phenyl ester ($C_6H_4(OH)COOC_6H_5$) of salicylic acid. Preserve it in well-closed containers in a cool place, and protected from light.

PROPERTIES: A white crystalline powder, having an aromatic odor and a characteristic taste. It is practically insoluble in water, soluble in 6 parts of alcohol, very soluble in chloroform, ether, and fixed or volatile oils.

PREPARATION: It is made by the action of dehydrating agents on a heated mixture of phenol and salicylic acid.

ACTION AND USES: It is used as an intestinal antiseptic. In the intestine, when in contact with alkaline fluids, it is decomposed into its component parts of phenol and salicylic acid which there exert their antiseptic action. It is given with bismuth subnitrate for diarrhœa. It passes through the stomach unchanged, but breaks down in the intestine, and because of this property it is used for coating enteric pills, protecting them from the action of the stomach juices.

Average dose: 0.3 Gm. or 5 grains.

Acidum Tannicum, Tannic Acid (Tannin, Gallotannic Acid), U. S. P.—A tannin usually obtained from nutgall. Preserve it in well-closed containers in a cool place, protected from light.

PROPERTIES: It is a yellowish-white to light brown, amorphous powder, glistening scales, or spongy masses, nearly odorless, and having a strong astringent taste. It is soluble in 1 part of glycerin and is very soluble in water or alcohol.

ACTION AND USES: It is an astringent, and hæmostatic. It is used in the form of an ointment for the treatment of hæmorrhoids and in an aqueous solution as an astringent mouth wash and gargle. It is an alkaloidal precipi-

tant and may be used as a chemical antidote in certain cases of alkaloidal poisoning. It is used extensively in the treatment of burns in the form of an aqueous solution or a jelly. It acts as an astringent, hinders the growth of bacteria, and "tans" the tissues in the burned areas, forming a crust over them which prevents the escape of fluids from the body. Fantus and Dyniewicz in the Journal of the American Medical Association of July 17, 1937, favorably report the use of Compound Solution of Tannic Acid in the treatment of burns and state that the solution does not decompose and may be kept on hand for use in the emergencies occasioned by extensive burns, the salicylic acid preventing deterioration. Following is their formula:

Potassium chloride	0.42 Gm.
Calcium chloride	0.84 Gm.
Acid salicylic	1.00 Gm.
Sodium chloride	10.50 Gm.
Acid tannic	100.00 Gm.
Distilled water to make	1,000.00 cc

Mix and permit to stand with occasional agitation until dissolved; filter.

Two formulas for the preparation of tannic-acid jelly are given in which phenol is used to prevent deterioration. Both may be prepared in quantity to be kept on hand for use in emergency.

5 per cent Tannic-Acid Jelly with Tragacanth and ½ per cent Phenol

Phenol	0.500
Tragacanth	3.000
Glycerin	42.500
Alcohol, 95 per cent	8.000
Tannic acid	5.000
Menthol	0.030
Distilled water	79.000

Dissolve tannic acid in the water, add the glycerin and phenol, and heat until the solution is hot. Dissolve menthol in the alcohol. Mix the tragacanth with the alcoholic solution and while stirring add the aqueous solution. Continue stirring until a uniform jelly results.

5 per cent Tannic-Acid Jelly with Starch and ½ per cent Phenol

Tannic acid	5.000
Phenol	0.500
Starch	5.500
Glycerin	42.000
Distilled water	47.000

Mix the starch with 10 cc of cold water. Mix the glycerin and the remaining water, dissolve the tannic acid and the phenol in this solution and heat to boiling. Continue the boiling, add all the starch mixture at once, and stir until a homogeneous jelly results before removing from heat. *Note*: Failure to jell will usually be due to withdrawal of heat too soon after starch mixture is added.

Acidum Tartaricum, Tartaric Acid, U. S. P.—A dibasic organic acid obtained from impure acid potassium tartrate (argol) in wine lees, by the action of

calcium carbonate and sulfuric acid on acid potassium tartrate, or by synthesis. It contains not less than 99.5 per cent of $C_2H_2(OH)_2(COOH)_2$.

PROPERTIES: It occurs in colorless, translucent crystals, or as a white, fine to granular crystalline powder, odorless, and having an acid taste. It is soluble in 0.75 parts of water, 3 parts of alcohol, and almost insoluble in chloroform and ether. It is stable in the air.

PREPARATION: It is made from the deposit in wine casks, which is composed principally of acid potassium tartrate. This acid potassium tartrate is converted into normal calcium tartrate (insoluble) in order to remove other impurities, then the pure calcium tartrate is treated with sulfuric acid, forming calcium sulfate and tartaric acid. The calcium sulfate is precipitated and the tartaric acid remains in solution, from which it is obtained by filtration and evaporation.

ACTION AND USES: It is used in the preparation of effervescent salts and drinks. It is contained in the white packet of a Seidlitz powder. Salts of tartaric acid are laxative (cream of tartar and Rochelle salt).

Average dose: 0.5 Gm. or 8 grains. (Rarely given internally.)

Cinchophenum, Cinchophen, N. F.—Cinchophen contains, when dried to constant weight at 100° C., not less than 99.5 per cent of phenyl-quinoline-carboxylic acid ($C_9H_5N.C_6H_5.COOH$).

PROPERTIES: It occurs in small, white or almost white, needle-like crystals or a fine powder, odorless, and has a bitter taste. It is stable in the air, is almost insoluble in cold water, but slightly soluble in hot water; slightly soluble in cold alcohol, but more readily soluble in hot alcohol.

ACTION AND USES: This compound is sold under the trade name of Atophan. It stimulates the kidneys to excrete more urine and has a selective action on the excretion of uric acid, which is increased in greater ratio than the increase in the amount of urine. Because of this selective action in increasing uric acid elimination it is used in the treatment of gout. Care must be taken in using it because it may cause damage to the kidney and sometimes has a dangerous effect on the liver.

Average dose: 0.05 Gm. or 8 grains.

Amylis Nitris, Amyl Nitrite, U. S. P.—A liquid containing not less than 80 per cent of $C_5H_{11}ONO$. Preserve it in hermetically sealed glass bulbs or tightly stoppered vials, in a cool place, protected from light.

PROPERTIES: It is a clear, yellowish liquid, of a peculiar ethereal, fruity odor and a pungent, aromatic taste. It is almost insoluble in water, but is miscible with alcohol or ether. It is very volatile even at low temperatures and is inflammable.

ACTION AND USES: Amyl nitrite, like other nitrites (glyceryl nitrite, etc.), is a vasodilator (dilates the blood vessels). Amyl nitrite is given by inhalation to relax spasms of blood vessels in angina pectoris, asthma, and other painful affections due to arterial spasms. It is supplied to the Navy in the form of glass pearls (ampules) containing 5 minims each. When it is to be administered the pearl is crushed in a handkerchief and the volatile amyl nitrite inhaled. Its action is almost instantaneous.

Average dose: 0.2 cc or 3 minims by inhalation.

Spiritus Æthylis Nitritis, Spirit of Ethyl Nitrite (Sweet Spirit of Nitre), U. S. P.—An alcoholic solution of ethyl nitrite (C_2H_5ONO) containing not less than 3.5 per cent nor more than 4.5 per cent of C_2H_5ONO. Preserve it in well-filled, small, tightly-stoppered bottles, in a cool and dark place, remote from fire.

PROPERTIES: It is a clear, mobile, volatile, and inflammable liquid of a pale yellow or faintly greenish-yellow tint, having a fragrant, ethereal, and pungent

odor, free from acridity, and a sharp, burning taste. When kept for a long time, or upon exposure to light and air, it acquires an acid reaction.

Action and Uses: It is a diuretic and diaphoretic. It is one of the ingredients contained in Brown Mixture. It frequently is given with solution of ammonium acetate.

Average dose: 2 cc or 30 minims.

Volatile oils, volatile-oil drugs, and preparations made from volatile-oil drugs.

Volatile oils are a class of substances having in common the properties of being volatile and almost insoluble in water; most of them are lighter than water, are soluble in ether and alcohol, have a highly characteristic odor, and possess antiseptic properties. They do not leave a permanent stain on paper like that left by a fixed oil. Most of them are obtained from plants where they exist naturally or are formed when the plant is brought in contact with water. They vary greatly in their chemical composition. The following classes of chemical compounds are found in volatile oils: Hydrocarbons, alcohols, aldehydes, esters, ketones, phenols and phenol derivatives, sulfur compounds, etc. All these classes of compounds are not found in any one oil but a volatile oil may contain one or more compounds belonging to one or more of the classes named. Oil of peppermint contains menthol which is an alcohol; oil of thyme contains thymol, which is a phenol; oil of gaultheria contains methyl salicylate, which is an ester, etc. The medicinal properties of the volatile oils vary greatly, due to the difference in their chemical composition.

Oleum Menthæ Piperitæ, Oil of Peppermint (Peppermint Oil), U. S. P.—A volatile oil distilled from the flowering plant of *Mentha piperita*, rectified by steam distillation, and yielding not less than 5 per cent of esters, calculated as menthyl acetate ($C_{10}H_{19}.C_2H_3O_2$), and not less than 50 per cent of total menthol ($C_{10}H_{19}.OH$), free and as esters. Preserve it in well-stoppered bottles, in a cool place, protected from light.

Properties: It is a colorless liquid, having a strong odor of peppermint and a pungent taste, followed by a sensation of cold when air is drawn into the mouth. It is very slightly soluble in water, but is soluble in 4 parts of 70 per cent alcohol.

Action and Uses: It is used as a flavoring, and as an aromatic stimulant and carminative. It is contained in Soda Mint Tablets.

Average dose: 0.1 cc or 1½ minims.

Menthol, Menthol, U. S. P.—An alcohol ($C_{10}H_{19}OH$), obtained from oil of peppermint or other mint oils, or prepared synthetically. Preserve it in well-closed containers in a cool place, protected from light.

Properties: It occurs in colorless, hexagonal crystals, usually needle-like, having a strong odor and taste like peppermint. When tasted it produces a sensation of warmth followed by cold when air is drawn into the mouth. It is slightly soluble in water; very soluble in alcohol, chloroform, ether, or in petroleum benzine; freely soluble in liquid petrolatum, fixed or volatile oils. When triturated with about an equal weight of camphor, thymol, or hydrated chloral the mixture becomes liquid.

Preparation: It is made by placing oil of peppermint in a freezing mixture; when the temperature reaches —22° C. the menthol precipitates from the oil.

Action and Uses: Externally it is applied to the skin as a local anæsthetic and cooling application for the relief of superficial neuralgias. It is extensively used in nose and throat sprays. It is applied in solution or ointment for the relief of itching skin diseases.

Average dose: 0.06 Gm. or 1 grain.

Spiritus Aurantii Compositus, Compound Spirit of Orange, U. S. P.—It contains oil of orange, oil of lemon, oil of coriander, oil of anise, and alcohol. It should be kept in completely filled, well-stoppered bottles in a cool, dark place.

ACTION AND USES: It is used as a flavoring and in the preparation of aromatic elixir.

Oleum Caryophylli, Oil of Clove (Oil of Cloves, Clove Oil), U. S. P.—A volatile oil distilled from the dried flower buds of *Caryophyllus aromaticus* and yielding not less than 82 per cent, by volume, of eugenol ($C_{10}H_{12}O_2$). Preserve it in well-stoppered bottles, in a cool place, protected from light.

PROPERTIES: It is a colorless or pale yellow liquid, becoming darker and thicker by age and by exposure to air, having the odor and taste of clove. It is soluble in two parts of 70 per cent alcohol.

ACTION AND USES: Internally it acts as a stimulant and carminative. Externally it is employed as a local anæsthetic, parasiticide, and counterirritant. In dental practice it is used to stop toothache by applying it, on a piece of cotton, to a previously cleaned tooth cavity. In microscopy it is used to clear tissues for mounting.

Average dose: 0.1 cc or 1½ minims. (When given internally it should be diluted with five times its volume of cottonseed oil.)

Eugenol, Eugenol, U. S. P.—An unsaturated, aromatic phenol, $C_6H_3.C_3H_5.OCH_3.OH$, obtained from oil of clove and from other sources. Preserve it in well-closed containers, in a cool place, protected from light.

PROPERTIES: It is a colorless or pale yellow, thin liquid, having a strongly aromatic odor of clove and a pungent and spicy taste. It becomes darker and thicker on exposure to air. It is soluble in two parts of 70 per cent alcohol; miscible with alcohol, chloroform, ether, or fixed oils.

ACTION AND USES: It is used in dental practice as a substitute for oil of clove.

Average dose: 0.1 cc or 1½ minims.

Tinctura Cardamomi Composita, Compound Tincture of Cardamom, U. S. P.—It contains the aromatic, carminative principles from cardamon seed, cinnamon, and caraway. It is colored red with cochineal. The menstruum is diluted alcohol containing a little glycerin.

ACTION AND USES: It is used as a carminative and flavoring agent.

Average dose: 0.4 cc or 1 fluidram.

Oleum Picis Rectificatum, Rectified Oil of Tar, U. S. P.—A rectified volatile oil distilled from pine tar.

PROPERTIES: It is a liquid having a reddish brown color and a strong, empyreumatic odor and taste. It is soluble in alcohol and insoluble in water.

PREPARATION: It is made from wood tar by subjecting it to distillation and collecting that portion of the distillate which is lighter than water. It is a mixture of phenols, hydrocarbons, acetic acid, and oil of turpentine.

ACTION AND USES: It is given internally in the treatment of chronic bronchitis, administered in the form of an emulsion; externally it is used in the treatment of skin diseases, in the form of an ointment.

Average dose: 0.2 cc or 3 minims.

Eucalyptol, Eucalyptol (Cineol), U. S. P.—An organic compound ($C_{10}H_{18}O$) obtained from the volatile oil of *Eucalyptus Globulus* and from other sources. Preserve it in well-closed containers, in a cool place protected from light.

PROPERTIES: It is a colorless, oily liquid, having a characteristic, aromatic, and distinctly camphoraceous odor, and a pungent, spicy taste. It is very slightly

soluble in water, miscible with alcohol, chloroform, ether, glacial acetic acid, and fixed or volatile oils.

ACTION AND USES: It is a stimulant expectorant, mild antiseptic, and anthelmintic. It is given in the treatment of chronic bronchitis and pulmonary tuberculosis. A mixture of 2 parts eucalyptol, 4 parts chloroform, and 45 parts of castor oil is used internally (given in two doses) in the treatment of uncinariasis (hookworm). Used locally in throat and nasal sprays and in the treatment of chronic skin diseases.

Average dose: 0.3 cc or 5 minims.

Fluidextractum Zingiberis, Fluidextract of Ginger, U. S. P.—Each 100 cc of the fluidextract contains not less than 4.5 Gm. of ether-soluble extractive, and each cc represents the medicinal activity of 1 gram of the drug (ginger). The active substances in ginger are a volatile oil and an aromatic resin.

ACTION AND USES: It is used in the preparation of syrup of ginger. It acts as a warm, stimulating carminative when taken internally and is a valuable remedy in the treatment of abdominal cramps.

Average dose: 0.5 cc or 8 minims (diluted with water).

Camphora, Camphora, U. S. P.—A ketone ($C_9H_{16}CO$) obtained from *Cinnamomum Camphora*, or produced synthetically. Preserve it in well-closed containers in a cool place, protected from light.

PROPERTIES: It occurs as white, translucent masses of granules of a tough consistence having a penetrating, characteristic odor and a pungent, aromatic taste. It is readily pulverizable in the presence of a little alcohol, ether, or chloroform. It is slightly soluble in water and freely soluble in alcohol, chloroform, ether, or in fixed or volatile oils.

PREPARATION: It is obtained by treating the branches and chipped wood of the camphor tree with steam. The camphor in the wood is volatilized by the hot steam and then condensed.

ACTION AND USES: It is a circulatory stimulant, mild antiseptic, slight rubefacient, and carminative. As a circulatory stimulant it is given hypodermically in sterilized oil. It is used as a mild antiseptic in nose and throat sprays, as a rubefacient in liniments, and as a carminative in diarrhœa mixtures (Squibb's Diarrhœa Mixture).

Average doses: By mouth 0.2 Gm. or 3 grains; by hypodermic 0.1 Gm. or 1½ grains.

Methylis Salicylas, Methyl Salicylate (Oil of Teaberry, Oil of Wintergreen, Oil of Sweet Birch), U. S. P.—It contains not less than 98 per cent of $C_6H_4(OH)COO.CH_3$. It is produced synthetically or is obtained by distillation from *Gaultheria procumbens* or from *Betula lenta*. The label must indicate whether the methyl salicylate has been made synthetically or distilled from either of the plants mentioned. Preserve it in well-stoppered bottles in a cool place, protected from light.

PROPERTIES: It is a colorless, yellowish or reddish liquid having the characteristic odor and taste of gaultheria. It is sparingly soluble in water, miscible with alcohol and glacial acetic acid, and is soluble in 7 parts of 70 per cent alcohol.

ACTION AND USES: It is antirheumatic and slightly antiseptic. Given internally its antirheumatic action is like that of the other salicylates. It is rapidly absorbed when rubbed on the skin or applied to the skin on a cloth. It is applied locally for the relief of rheumatic pains in the joints. The synthetic oil is on the Supply Table. It is cheaper than the natural oil and is believed to be identical in its medicinal properties.

Average dose: 0.75 cc or 12 minims.

Thymol, Thymol, U. S. P.—A phenol ($C_6H_3(CH_3)(OH)(C_3H_7)$) occuring in the volatile oil of *Thymus vulgaris* and in some other volatile oils. Preserve it in well-closed containers.

PROPERTIES: It occurs in large colorless crystals, having an aromatic, thyme-like odor and a pungent, aromatic taste, with a slight caustic effect upon the lips. It is soluble in 1,000 parts of water, 1 part of alcohol, 0.7 part of chloroform, 1.5 parts of ether, 1.7 parts of olive oil, and in glacial acetic acid and in fixed or volatile oils. When triturated with about an equal weight of camphor or menthol, the mixture liquefies.

ACTION AND USES: Thymol is used as an anthelmintic and antiseptic. As an antiseptic it is employed in mouth washes, gargles, and sprays. As an anthelmintic it is given for the cure of hookworm disease. Oils should not be given while thymol is in the intestinal tract because they cause it to be absorbed, with resulting symptoms of poisoning. Its administration should be preceded and followed by administrations of magnesium sulfate.

Average dose: Antiseptic, 0.125 Gm. or 2 grains; anthelmintic, 1 Gm. or 15 grains.

Thymolis Iodidum, Thymol Iodide (Aristol), U. S. P.—Chiefly dithymoldiiodide ($C_6H_2.CH_3.C_3H_7.OI$). It contains, when dried to constant weight over sulfuric acid, not less than 43 per cent of iodine. Preserve it in well-closed containers, protected from light.

PROPERTIES: It is a reddish-brown, or reddish-yellow bulky powder with a very slight, aromatic odor. It is insoluble in water or glycerin; slightly soluble in alcohol and very soluble in chloroform, ether, and in fixed or volatile oils.

PREPARATION: It may be made by adding an aqueous solution of iodine and potassium iodide to an aqueous solution of sodium hydroxide and thymol with constant stirring. Thymol iodide is precipitated from this mixture.

ACTION AND USES: It is a valuable antiseptic dusting powder. It is used in surgery as a substitute for iodoform, and as an external application to ulcers and skin diseases, either in the form of dry powder or ointment. It commonly is known as Aristol.

Emplastrum Sinapis, Mustard Plaster (Mustard Paper), U. S. P.—A uniform mixture of powdered black mustard (deprived of its fixed oil) and a solution of rubber, spread on paper, cotton cloth, or other fabric. It should be one square decimeter (16 square inches) in size and contain not less than 2.5 grams of black mustard deprived of its fixed oil.

PROPERTIES: When moistened thoroughly with tepid (not hot) water and applied to the skin, the plaster produces a decided warmth and reddening of the skin within 5 minutes. The irritating effect is produced by the volatile oil of mustard. This oil is liberated when mustard is mixed with water.

ACTION AND USES: It is an extensively used counterirritant. It is used for the relief of congestion and pain in the chest, abdomen, joints, or muscles.

Tinctura Capsici, Tincture of Capsicum, U. S. P.—It is a 10 per cent tincture, made by exhausting the active principles contained in Cayenne pepper with alcohol. It has a light reddish color and the fiery taste of Cayenne pepper.

ACTION AND USES: Taken internally it stimulates the secretions of the salivary, gastric, and intestinal glands. It is especially valuable in gastritis due to alcoholism.

Average dose: 0.5 cc or 8 minims.

Oleum Santali, Oil of Santal (Santalwood Oil, Oil of Sandalwood), U. S. P.—A volatile oil distilled from the dried heart-wood of *Santalum album*, yielding not less than 90 per cent of alcohols, calculated as santalol ($C_{15}H_{24}O$). Preserve

it in well-stoppered, amber-colored bottles in a cool place, protected from light.

PROPERTIES: It is a pale yellow, somewhat viscid, oily liquid; soluble in 5 parts of 70 per cent alcohol and having the characteristic odor and taste of sandalwood.

ACTION AND USES: It is given internally as a stimulant and disinfectant to the mucous membranes of the genito-urinary tract. In overdoses it is very irritating to the genito-urinary tract, and therefore should be given with care. Its principal use is in the treatment of chronic gonorrhœa.

Average dose: 0.5 cc or 8 minims (in capsules, three times a day).

Resins, oleoresins, gum-resins, balsams, and their preparations.

Resins are natural, solid or semisolid plant exudations which usually are the oxidation products of the terpene group of volatile oils. They are complex in chemical composition, in which they show no uniformity, and apparently have as their chief constituents resin acids, resin esters, and resenes. Some are acid in character and form resin soap when combined with alkalies. They are hard, brittle, noncrystalline solids, fusible but not volatile, insoluble in water but soluble mostly in alcohol and ether, have little taste, burn with a smoky flame when ignited in the air, and soften or melt at moderate temperatures. They are transparent when pure but when they contain water are opaque and no longer hard and brittle. Resins are known as *natural resins* which occur as plant exudations, and *prepared resins* which are made in various ways. *See* under Resinæ in chapter on Pharmacy).

Oleoresins are of two types, natural and prepared. Natural oleoresins are mixtures of volatile oil and resin and are obtained generally from natural fissures or from incisions made in the trunks of the trees in which they occur. (For prepared oleoresins *see* under Oleoresinæ in chapter on Pharmacy).

Gum-resins are natural plant exudations composed of gum and resin. The gummy plant substances called *gums* are amorphous (shapeless), transparent or translucent, probably glucosidal in nature, and as the chemical composition of some of their constituents is similar to starch are classified with carbohydrates (*see* under Sugars and substances containing sweet principles, p. 241). They are all insoluble in alcohol (differing in this respect from resins), some are completely soluble in water, others swell in water and form a paste or jelly, and a few are almost insoluble. When gum-resins are rubbed up with water they form an emulsion as the gum dissolves to form a mucilage which holds the resin in suspension.

Balsams are natural oleoresins which contain benzoic or cinnamic acids or their esters, or other aromatic acids. When a natural resin contains benzoic or cinnamic acids and is therefore aromatic, it is known as a balsamic resin.

Oleum Terebinthinæ, Oil of Turpentine (Spirits of Turpentine), U. S. P.—The volatile oil distilled from the oleo-resin obtained from *Pinus palustris* and other species of *Pinus*. Preserve it in well-closed containers.

PROPERTIES: It is a colorless liquid having a characteristic odor and taste, both of which become stronger and less pleasant on aging or exposure to the air. Almost insoluble in water but soluble in 5 parts of alcohol.

ACTION AND USES: The rectified oil of turpentine, U. S. P., should be used internally and oil of turpentine externally. When given internally it acts as a diuretic, expectorant, and anthelmintic. Externally it is used as a counter-irritant and rubefacient.

Average dose: 0.3 cc or 5 minims (of the rectified oil).

Terpini Hydras, Terpin Hydrate, U. S. P.—The hydrate ($C_{10}H_{18}(OH)_2+H_2O$) of the dihydric alcohol terpin. Preserve it in well-closed containers, in a cool place, and protected from light.

Properties: It is a colorless, lustrous, white powder, almost odorless, having a slight aromatic and bitter taste. It is soluble in 200 parts of water and in 13 parts of alcohol. It effloresces in dry air.

Action and Uses: It has a stimulating action upon mucous membranes. Its action is expectorant, diuretic, and slightly antiseptic. Its principal use is as an expectorant in the treatment of chronic bronchitis. It is administered in the form of an elixir.

Average dose: 0.25 Gm. or 4 grains.

Tinctura Myrrhæ, Tincture of Myrrh, U. S. P.—It is made by extracting by maceration, the soluble principles from 200 Gm. of powdered myrrh with sufficient alcohol to obtain 1,000 cc of finished tincture.

Properties: It is a dark reddish-brown liquid, having the balsamic odor of myrrh, and a bitter, aromatic taste. When mixed with water the resin contained in the alcoholic solution is precipitated. Myrrh is a gum resin and contains 3 to 8 per cent of an oxygenated volatile oil, a bitter principle, about 50 to 60 per cent of gum, and 25 to 40 per cent of resin.

Action and Uses: It is an astringent. It is rarely used internally. It is used locally as a mouth wash, diluted with water in the proportion of about 1 to 20, in the treatment of stomatitis, spongy gums, sore throat, ptyalism, etc.

Average dose: 1 cc or 15 minims.

Balsamum Peruvianum, Peruvian Balsam (Balsam of Peru, Peru Balsam, Indian Balsam, U. S. P.—A balsam obtained from *Toluifera Pereiræ.* It contains about 60 per cent of a volatile oil and about 30 per cent of resin.

Properties: It is a viscid liquid of a dark-brown color having an agreeable, vanilla-like odor, and a bitter, acrid taste. It is almost insoluble in water, soluble in alcohol or chloroform, and partly soluble in ether.

Action and Uses: 95 per cent solution in castor oil is used as a stimulating dressing for sluggish granulations and chronic indolent ulcers. It is a valuable parasiticide in ringworm, pediculosis (crab lice), and scabies; for this purpose it is used in the form of an ointment consisting of 20 parts balsam of Peru, 50 parts cottonseed oil, and 100 parts petrolatum. In the treatment of scabies it is used like sulfur ointment (hot bath before, etc.). There may be added to this ointment 10 per cent of sulfur to increase its efficiency in the treatment of scabies.

Tinctura Benzoini Composita, Compound Tincture of Benzoin (Friars' Balsam), U. S. P.—It is a dark-brown alcoholic liquid, made by extracting, by maceration, the alcohol-soluble principles from benzoin, 100 Gm.; aloes, 20 Gm.; storax, 80 Gm.; and balsam of tolu, 40 Gm., with sufficient alcohol to make 1000 cc of finished tincture.

Action and Uses: It is used in steam atomizers as an inhalant in the treatment of croupous affections of the throat and bronchi. If a steam atomizer is not available, the inhalations may be given by adding a teaspoonful of tincture to a glassful of boiling water and inhaling the vapor. It also is used as a protective for ulcers, fissures of the lips and anus, bedsores, cracked nipples, etc. It rarely is used internally.

Average dose: 2 cc or 30 minims.

Oleoresina Aspidii, Oleoresin of Aspidium (Oleoresin of Male Fern), U. S. P.—Made by extracting the ether-soluble principles from Aspidium by percolation with a menstruum of ether. After percolation the ether is evaporated off, leaving the oleoresin of aspidium. It should be preserved in well-stoppered bottles. On standing, there is deposited in the bottom of the bottle a granular crystalline substance which should be thoroughly mixed with the liquid portion before use.

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ACTION AND USES: Used as a tæniacide (kills tapeworms). Castor oil or other fixed oils should not be given while oleoresin of aspidium is in the intestinal tract, because they cause absorption of the oleoresin and thus may cause toxic symptoms.

Average dose: 4 Gm. or 60 grains. Only one dose a day.

Fixed oils, fats, and soaps.

Fixed oils are so called because they leave a stain on paper or cloth that will not wash out, nor will it volatilize when subjected to mild heat. In this respect they differ from volatile oils. Solid substances that leave a similar stain are called fats. Fixed oils are found principally in the vegetable kingdom, and the fats are obtained from the animal kingdom. Fixed oils and fats are classed together because of the close chemical relationship that exists between them. They are composed principally of mixtures of glycerides of organic acids (esters). The principal acids that are combined with glyceryl radicals (C_3H_5) in these glycerides are: Oleic, palmitic, stearic, linoleic, and ricinoleic. The glycerides of these acids are liquids, except those of stearic and palmitic acids. Most fats and oils in common use are composed of glycerides of two or more of the above acids. The consistence of a fat or oil is governed by the proportion in which the solid and liquid glycerides are contained in it. Cottonseed oil is composed principally of glyceryl oleate (olein), while beef tallow, a solid, is composed principally of glyceryl stearate (stearin), etc. If the basic glyceryl radical (C_3H_5) in a glyceride is displaced by an alkali metal, like sodium, sodium stearate, sodium oleate, or sodium palmitate (soaps) are formed according to the acid in the glyceride; the glyceryl radical (C_3H_5) is set free to combine with hydroxyl (OH) groups that were attached to the sodium and form glycerin. This reaction is known as saponification. Rancidity is a condition in fixed oils and fats due to decomposition of the glycerides under the influence of air (oxygen), heat, and albuminous matter, resulting in the liberation of the fatty acids and generation of volatile acids that have a distinct odor.

Oleum Gossypii Seminis, Cottonseed Oil, U. S. P.—A fixed oil obtained from seeds of cultivated varieties of *Gossypium herbaceum*, or other species of *Gossypium*. It is made by expression. Preserve it in well-closed containers, protected from light.

PROPERTIES: It is a pale, yellow, oily liquid, odorless or nearly odorless, and having a bland taste. It is almost insoluble in water; slightly soluble in alcohol; and is miscible with ether, chloroform, and petroleum benzine. It is readily saponified by strong solutions of alkalies forming soap.

ACTION AND USES: It is used in the preparation of liniments. Cottonseed oil and its derivatives are used extensively as food products. It also is used in large quantities in the manufacture of soap.

Average dose: 8 cc or 2 fluidrams.

Oleum Ricini, Castor Oil, U. S. P.—A fixed oil obtained from the seeds of *Ricinus communis*. Preserve it in well-closed containers.

PROPERTIES: It is a pale-yellowish or almost colorless, transparent, viscid liquid, having a faint, mild odor and a bland, afterwards slightly acrid and generally nauseating taste. It is almost insoluble in water and is soluble in equal parts of alcohol and in one and one-half times its volume of liquid petrolatum.

ACTION AND USES: It is used extensively as a simple purgative. It increases the intestinal secretions and stimulates the peristaltic movements of the intestine. Its disagreeable taste may be disguised partially by administering it

between a layer of peppermint water below and a layer of compound tincture of cardamon above the oil.

Average dose: 15 cc or 4 fluidrams.

Oleum Morrhuæ, Cod Liver Oil (Oleum Jecoris Aselli), U. S. P.—The partially destearinated fixed oil obtained from the fresh livers of *Gadus morrhua* (codfish) and other species of the family *Gadidæ*. Cod Liver Oil contains in each gram at least 600 U. S. P. Units of Vitamin A and at least 85 U. S. P. Units of Vitamin D. Preserve it in a cool place in well-closed containers which have been thoroughly dried before filling.

PROPERTIES: It is a thin, oily liquid, having a peculiar, slightly fishy, but not rancid odor, and a fishy taste. It is almost insoluble in water but is slightly soluble in alcohol.

PREPARATION: The oil is obtained from the fresh fish livers by boiling them with water and skimming off the separated oil.

ACTION AND USES: It is used as a tonic in the treatment of wasting diseases. The ease with which it is assimilated makes it an excellent food. Its beneficial effects are due principally to the presence of large amounts of Vitamin A and Vitamin D. Cod Liver Oil is also used as a local application to promote healing of burns on the body.

Average dose: 10 cc or 2½ fluidrams.

Liquor Ergosterolis Irradiati, Solution of Irradiated Ergosterol (Viosterol in Oil), U. S. P.—A solution of ergosterol in corn oil, activated by irradiation with ultraviolet rays. It contains in each gram not less than 10,000 U. S. P. Units of Vitamin D.

PROPERTIES: A clear, light yellowish, oily liquid. It is almost odorless and has a bland taste. It should be preserved in small, well-stoppered bottles, in a cool place.

ACTION AND USES: It is used in prophylaxis and treatment of rickets and infantile tetany, and in other conditions due to faulty calcium and phosphorus assimilation. This preparation does not contain any Vitamin A. Care must be exercised in giving this preparation to avoid hypercalcæmia caused by large doses over a long period.

Average dose: 0.3 cc or 5 minims.

NOTE.—Through biochemical investigation into the physiological action of Vitamin D it was discovered that when food mixtures which caused the production of rickets in young animals were exposed to ultraviolet rays they became endowed with properties protecting the animals against the disease. Further research disclosed that the protective properties were concerned with a constituent of the fatty part of the ration and this constituent was finally found to be a substance known as ergosterol. Ergosterol was originally isolated as a constituent of ergot but is now obtained from other substances, mainly yeast. Either in crystalline form or in solution, when it is subjected to carefully regulated ultraviolet radiation, ergosterol develops an antirachitic (Vitamin D) potency enormously greater than that of Cod Liver Oil. The Council of Pharmacy and Chemistry of the American Medical Association has adopted the term Viosterol to designate irradiated ergosterol, and Viosterol in Oil to designate a preparation containing this substance dissolved in a vegetable oil.

Halibut Liver Oil with Viosterol, N. N. R.—Halibut Liver Oil to which has been added sufficient viosterol (irradiated ergosterol) to assure a potency of not less than 9,000 Vitamin D units (U. S. P. X-Revised, 1934) per gram; the halibut liver oil is adjusted (when necessary) to have a Vitamin A potency of

not less than 44,800 units (U. S. P. X-Revised, 1934) of Vitamin A per gram by the addition of fish liver oils.

ACTION AND USES: The action and use are the same as for Cod Liver Oil. This preparation is much richer in both Vitamin A and Vitamin D than Cod Liver Oil and the dose is correspondingly smaller.

Average dose: For infants 10 drops daily and for adults 20 drops daily.

Oleum Theobromatis, Theobroma Oil (Cacao Butter, Cocoa Butter, Oil of Theobroma), U. S. P.—The fat obtained from the roasted seed of *Theobroma Cacao*. Preserve it in a cool place.

PROPERTIES: It is a yellowish-white solid, having a faint, agreeable odor, and a bland, chocolate-like taste. It is insoluble in water, slightly soluble in alcohol, and freely soluble in ether or chloroform. It melts between 30° and 35° C. (86° and 95° F.). It is usually brittle at temperatures below 25° C.

ACTION AND USES: It is used as a vehicle in the preparation of suppositories because it melts slightly below the temperature of the body, sets free any medicinal substance incorporated with it, and allows the medicine to come in contact with the mucous membranes. It also is used in the preparation of skin foods (ointment-like preparations) and as a lubricant in massage. It is not given internally.

Adeps, Lard, U. S. P.—The purified internal fat of the abdomen of the hog. Preserve it in a cool place in well-closed containers which are impervious to fat. *Adeps benzoinatus*, (*benzoinated lard*), U. S. P., is a lard that has been treated with Siam benzoin to prevent it from turning rancid. In the preparation of benzoinated lard for use in warm climates the Pharmacopœia states that 50 Gm. of white wax (or more if necessary) may replace an equal amount of the lard in order to raise its melting point. Supply Table lard contains 12 per cent of white wax.

PROPERTIES: Lard is a soft, unctuous mass having a faint odor and a bland taste, and free from rancidity. It melts between 36° and 42° C., is insoluble in water, slightly soluble in alcohol, and readily soluble in ether, chloroform, and petroleum benzine.

ACTION AND USES: Benzoinated lard is used principally as an ointment base.

Adeps Lanæ, Wool Fat (Anhydrous Lanolin, Refined Wool Fat), U. S. P.—The purified, anhydrous, fat-like substance obtained from the wool of the sheep. Preserve it in a cool place in well-closed containers which are impervious to fat.

PROPERTIES: It is a brownish-yellow, tenacious, unctuous mass having not more than a slight odor. It is insoluble in water, but mixes with its own weight of water without losing its ointment-like character.

ACTION AND USES: It is used principally as an ointment base. It will permit 100 per cent of its weight of water to be incorporated with it, which makes it an excellent base to use when a large volume of an aqueous liquid is to be incorporated in an ointment. Unlike lard and most other animal fats, it does not turn rancid.

Cera Alba, White Wax, U. S. P.—It is yellow wax which has been bleached.

PROPERTIES: It is a yellowish-white solid, somewhat translucent in thin layers, having a faint characteristic odor, practically tasteless, and free from rancidity.

ACTION AND USES: It is used to stiffen ointments in warm climates, and it also is used in the preparation of cerates (stiff ointments). It is sometimes adulterated wth paraffin.

Sapo Durus, Hard Soap, U. S. P.—Soap prepared from olive oil and sodium hydroxide. Preserve in well-closed containers.

PROPERTIES: It occurs as a white or whitish solid in the form of bars, hard, yet easily cut when fresh, or as a fine, white or yellowish-white powder, having a faint peculiar odor, free from rancidity, and a disagreeable alkaline taste. It is soluble in water and in alcohol.

ACTION AND USES: It is used as a pill excipient in the preparation of pills containing resinous drugs. It is used also in liniments and plasters. It is on the Supply Table under the name of Castile Soap. It originally came from Castile, Spain.

Sapo Mollis, Soft Soap, U. S. P.—It is soap made by the action of sodium hydroxide and potassium hydroxide on linseed oil.

PROPERTIES: It is a soft, unctuous, yellowish-white to brownish-yellow mass, having a slight characteristic odor and an alkaline taste. It is soluble in water and alcohol.

ACTION AND USES: It is used in the preparation of liniment of soft soap (tincture of green soap). Tincture of green soap is used extensively for surgical cleansing.

Linimentum Camphoræ et Saponis, Camphor and Soap Liniment (Linimentum Saponis, U. S. P. X., Soap Liniment), U. S. P.—Soap liniment is supplied to the Navy in powdered form consisting of soap, camphor, and oil of rosemary. The liniment is made from this powder by dissolving it in 70 per cent alcohol, allowing it to stand 24 hours and filtering.

ACTION AND USES: It is applied externally with massage as a rubefacient and also is used as a vehicle in the preparation of other more active liniments (chloroform liniment).

Amylaceous and mucilaginous substances.

Amylaceous substances partake of the nature of starch which has the same chemical composition as cellulose ($C_6H_{10}O_5$) and to which some of its properties are closely allied. Starch is stored in plant cells in the form of granules of various shapes such as ovoid, spherical, polygonal, etc. Starches from different plants can be recognized by the shape of their granules as seen through a microscope.

Amylum, Starch (Cornstarch), U. S. P.—The starch separated from the grain of *Zea Mays.*

PROPERTIES: It occurs in the form of a fine powder or irregular, angular, white masses, inodorous, and having a slight characteristic taste. It is insoluble in cold water and in alcohol. The individual grains are colored deep blue by iodine test solution. Cornstarch can be distinguished from other kinds of starch by the shape and size of the grain and the relative position of the hilum when viewed under a microscope. Boiled starch gives a deeper blue reaction with iodine than raw starch.

ACTION AND USES: It is used externally in dusting powders; internally as a demulcent; and in the form of starch paste in water as a vehicle for the administration of drugs by rectum. *Starch paste is the best antidote for iodine poisoning.*

Mucilaginous substances are gums and other plant principles which in combination with water form viscid, sticky liquids. Gums have been briefly described under Gum-resins on page 234; other mucilaginous plant principles are *dextrin,* made from starch by oxidation with nitric acid, *arabic acid,* the active principle of acacia, *bassorin,* the chief constituent of tragacanth, *cerasin,* the exudation from peach and plum trees, and *pectin,* found in fruit juices. Dextrin is the substance which gives a loaf of bread its glossy outer surface and the high polish to well-ironed linen.

Acacia, Acacia (Gum Arabic), U. S. P.—The dried gummy exudation of *Acacia Senegal* and other African species of *Acacia*.

PROPERTIES: It occurs in yellowish-white to light amber, translucent, brittle, spheroidal tears or angular fragments, inodorous, and having a mucilaginous taste. These tears or fragments are reduced to a white, granular powder and supplied under the name granular acacia. Acacia is completely soluble in water and insoluble in alcohol and very sensitive to certain reagents. It is precipitated from aqueous solutions by alcohol, tincture of ferric chloride, solution of lead subacetate, and saturated solution of borax, and should not be prescribed with these substances.

ACTION AND USES: It is used as a demulcent and as an emulsifying agent; also as an excipient in pill making. Mucilages and syrups made with acacia do not keep well unless sterilized.

Agar, Agar (Agar-agar, Chinese or Japanese Gelatin), U. S. P.—The dried mucilaginous substance extracted from *Gelidium corneum* and other species of *Gelidium* and closely related algæ. It contains not more than 1 per cent of foreign organic matter, and yields not more than 1 per cent of acid-insoluble ash, and not more than 18 per cent of moisture.

PROPERTIES: Thin, translucent, membranous, agglutinated pieces or cut, flaked, or granulated; yellowish or brownish-white in color; brittle when dry and tough when damp; with a slight odor and a mucilaginous taste. Insoluble in cold water but slowly soluble in hot water.

ACTION AND USES: In bacteriological work it is used in culture media. Is given internally to give moisture and bulk to the intestinal contents in chronic constipation.

Average dose: 10 Gm. or 2½ drams.

Tragacantha, Tragacanth (Gum Tragacanth), U. S. P.—The dried gummy exudation from *Astragalus gummifer* or other Asiatic species of *Astragalus*. It is supplied in unground fragments, straight or spirally twisted ribbon-like pieces, and in ground white powder, and consists of bassorin and a soluble gum.

PROPERTIES: With 50 parts of water it swells and forms a smooth, nearly uniform, stiff, opalescent mucilage. It does not dissolve in water. The best mucilage is obtained from the whole gum or flake tragacanth. Several days should be allowed for obtaining a uniform mucilage of maximum gel strength. To quickly make a mucilage from powdered tragacanth, according to "The Art of Compounding" by Scoville and Powers, it is best to first moisten the powder with a small amount of alcohol or glycerin, then add a large proportion of water, and shake and stir. In fragments tragacanth is whitish or yellowish-white in color, translucent and horny; in the powder it is white in color. It is odorless and has an insipid, mucilaginous taste.

ACTION AND USES: It is used in the preparation of emulsions to increase consistence and retard creaming. It is used as a suspending medium in lotions, mixtures, and cosmetic preparations. It is used in the preparation of surgical lubricants. One formula for such a lubricant is:

Tragacanth	12 Gm.
Alcohol	10 cc.
Salicylic acid	1 Gm.
Boric acid	8 Gm.
Sodium benzoate	2 Gm.
Glycerin	45 cc.
Water	200 cc.

Add the alcohol to the powdered tragacanth and stir. Dissolve the salicylic acid in the alcohol before adding it to the tragacanth. Add the glycerin. Add water containing boric acid and sodium benzoate and stir. Heat on water-bath for 1 hour. Pour into sterilized tubes while hot.

Sugars and substances containing sweet principles.

Included in the general classification of carbohydrates are sugars, starches, gums, and celluloses, all of which are of great importance in the life of plants and have similar chemical compositions in that they all contain C, H, and O, but in different proportions. (*See* p. 720.) In the chemical formulas of these substances the hydrogen and oxygen atoms attached to the carbon atoms in the molecule are present in exactly the same proportion as in water, i.e., there are always twice as many hydrogen atoms as oxygen atoms. Because of this peculiarity the term "carbohydrates" was given to the class of substances in which that characteristic was found. Of the substances mentioned as being classed as carbohydrates one class of sugars has the formula $C_6H_{12}O_6$, another the formula $C_6H_{22}O_{11}$, and starches, celluloses, and constituents in gums have the formula $C_6H_{10}O_5$.

Sugars and saccharine substances having the nature of sugars are distinguished by their sweetness of taste and their solubility in water. They are classified according to their chemical composition and their behavior toward agents such as mineral acids and enzymes which cause them to alter their composition by the addition of molecules of water and form new compounds. This forming of new compounds through the addition of molecules of water is termed *hydrolysis* and the agents which are instrumental in bringing about the alteration in composition are known as *hydrolytic agents.* Some sugars cannot be split up further by the action of hydrolytic agents and are known as *monosaccharides* and have the formula $C_6H_{12}O_6$; others that split up into two molecules of monosaccharides are known as *disaccharides* and have the formula $C_{12}H_{22}O_{11}$; and those that split up into three molecules of monosaccharides are known as *trisaccharides* and have the formula $C_{18}H_{32}O_{16}$. Sugars which split up into more than three molecules of monosaccharides are called *polysaccharides,* in which group fall the sugars into which, because of their close chemical relationship to sugars, starches and celluloses can be converted. The polysaccharides obtained from starches and celluloses have the formula $(C_6H_{10}O_5)_n$. Sugars have the ability to rotate the plane of polarized light to the right or to the left and therefore can be classified as dextrorotatory or levorotatory after the direction in which the polarized light is rotated has been determined by a polariscope or by a polarimeter. *Dextrose* is an example of a dextrorotatory sugar and *levulose* of a levorotatory sugar.

Glucosum, Glucose (Syrupy Glucose, Liquid Glucose, Corn Syrup), U. S. P.—A product obtained by the incomplete hydrolysis of starch. The syrupy glucose obtained by one process of manufacture consists of 30 to 40 per cent of dextrose (*d*–Glucose, $C_6H_{12}O_6$), 30 to 40 per cent of dextrin, small amounts of other carbohydrates, notably maltose, and water.

PROPERTIES: A colorless or yellowish, thick, syrupy liquid, odorless or nearly so, and having a sweet taste. It is very soluble in water but only sparingly soluble in alcohol. It is the principal source of Dextrose, U. S. P. The term glucose is frequently applied incorrectly to dextrose but should never be used when reference to dextrose is intended.

ACTION AND USES: Glucose is given per rectum as a food when feeding by stomach is impossible, and may be used to combat various types of shock. In

Pharmacy it is used as a diluent in pilular extracts and has replaced glycerin in the commercial manufacture of many pharmaceutical preparations. If the U. S. P. preparation of glucose is not available ordinary commercial corn syrup is a satisfactory substitute.

Glucose should not be given intravenously, intramuscularly, or intraabdominally as it contains substances not suitable for introduction into the body in those ways, and should not be used if dextrose is obtainable.

Dextrosum, Dextrose, (*d*–Glucose), U. S. P.—A sugar ($C_6H_{12}O_6.H_2O$) usually obtained by the hydrolysis of starch, the conversion temperature being higher and the time of conversion longer than in the preparation of syrupy glucose. Preserve it in well-closed containers.

Properties: Dextrose represents the complete hydrolysis of starch and occurs as colorless crystals, or a white, crystalline or granular powder, odorless, and having a sweet taste. It is soluble in 1 part of water and in about 59 parts of alcohol at 25° C., and is more soluble in boiling water and boiling alcohol. An aqueous solution (1 in 20) is neutral to litmus paper and is dextrorotatory. It loses not less than 8 per cent and not more than 10 per cent of its weight when dried to constant weight at 105° C. When dissolved in water and subjected to prolonged boiling it undergoes very little alteration. It is less sweet, less soluble in water, and more soluble in alcohol than cane sugar (sucrose). Strong mineral acids hardly act on dextrose but easily destroy cane sugar. It is sometimes called *grape sugar* because the principal sugar in grapes is dextrose, and has also been termed *starch sugar* and *corn sugar.*

Action and Uses: Dextrose is used in large quantities for its nutritive value and is usually given intravenously or injected into the subcutaneous tissues by hypodermoclysis. Dextrose is used whenever it is desired to raise the percentage of blood sugar as in combating traumatic, postoperative, and insulin shock, in preparing feeble patients for operation, and in the treatment of threatened diabetic coma and of acidosis resulting from diabetes or starvation. When dextrose is given in diabetic conditions insulin, in the proportion of 1 unit to 5 Gm. of dextrose, is usually given subcutaneously at the same time to promote sugar metabolism. It is used extensively as a source of water supply in cases of dehydration where it is impracticable to give water by the usual methods, and in tests to determine sugar tolerance. In hypertonic solutions (those whose osmotic tension exceeds that of blood serum) it promotes diuresis and aids certain types of œdema.

Average dose: The N. F. preparations of Dextrose are usually used when it is to be administered. The general dose of *Ampullæ Dextrose, Ampuls of Dextrose,* N. F., is 50 cc, containing about 25 Gm. of Dextrose; of *Ampullæ Dextrosi et Sodii Chloridi, Ampuls of Dextrose and Sodium Chloride,* N. F., is 10 cc, containing about 2.5 Gm. of Dextrose and 1.5 Gm. of Sodium Chloride; and of *Liquor Dextrosi et Sodii Chloridi, Isotonici, Isotonic Solution of Dextrose and Sodium Chloride,* N. F., which contains in each 100 cc not less than 2.3 Gm. and not more than 2.5 Gm. of Anhydrous Dextrose, and not less than 0.4 Gm. and not more than 0.425 Gm. of Sodium Chloride, is 1000 cc intravenously.

Sucrosum, Sucrose (Saccharum, Sugar, Cane Sugar, Beet Sugar), U. S. P.—A sugar ($C_{12}H_{22}O_{11}$) obtained from *Saccharum officinarum, Beta maritima,* and other sources.

Properties: It occurs in colorless or white crystals, crystalline masses or blocks, or a white crystalline powder, odorless, with a sweet taste. It is stable in the air and is soluble in ½ part of water and 170 parts of alcohol, at 25° C., and in slightly more than ⁲⁄₁₀ part of boiling water. It is insoluble in chloroform and in ether. An aqueous solution (1 in 20) is neutral to litmus paper.

Sucrose is dextrorotatory but by the action of an enzyme or by heating with diluted acids is converted into the fermentable mixture called invert-sugar which is levorotatory. If a dilute aqueous solution of sucrose is exposed to warm, dust-laden air it is converted into alcohol, carbon dioxide, and eventually acetic acid.

Action and Uses: Sucrose is used principally in the making of pharmaceutical preparations such as syrups, troches, masses, confections, etc. The best sugar for general pharmaceutical uses is the kind known technically as "granulated", one of very high purity is preferable for making pharmaceutical syrups, and a finely granulated type known as "confectioner's" or "XXXX" sugar is especially suitable for the making of troches. Sucrose has a high food value but its use should be restricted or eliminated in diabetes mellitus, in obesity, and during the existence of fermentative changes in the stomach and intestine.

Glycyrrhiza, Glycyrrhiza (Licorice, Licorice Root), U. S. P.—The dried rhizome and roots of varieties of *Glycyrrhiza glabra* known in commerce as Spanish Licorice and Russian Licorice, and of other varieties, yielding a yellow, sweet wood.

Properties: It contains the sweet principle *glycyrrhizin*, a salt of *glycyrrhizic acid*, and an oleoresinous substance which gives Glycyrrhiza its slightly acrid taste. It has a distinctive odor, a yellowish-brown, dark brown, or pale yellow color externally and a yellow or pale yellow color internally, and yields not more than 2.5 per cent of acid-insoluble ash.

Action and Uses: Its value in Pharmacy is due to the sweet principle it contains. The fluidextract is on the Supply Table and is used in making Brown Mixture. Both the extract and the fluidextract of Glycyrrhiza are excellent preparations for masking the taste of bitter drugs, like quinine, but acids should not be added as they precipitate the sweet principle.

Average dose: 2 cc or 30 minims of the fluidextract.

Glucosides, glucosidal drugs, and preparations made from glucosidal drugs.

Glucosides are organic plant principles which, when treated with diluted acids or enzymes, decompose by hydrolysis into a sugar and one or more other substances. The sugar into which glucosides split is usually any one of a number of bodies having the formula of glucose, $C_6H_{12}O_6$; the other substances are usually of a complex character and in most cases are compounds of benzene. A few glucosides contain nitrogen but most are nonnitrogenous. *Saponins* is the name given to a group of glucosides that are readily soluble in water and produce a froth, like soap-suds, when an aqueous solution is shaken. They are good emulsifying agents and aqueous solutions of some of them are used in place of soap for cleansing purposes. Many are markedly toxic in their physiological action and will dissolve or hæmolyze red blood cells. The toxic saponins are termed *sapotoxins*. Medicinally, glucosides are very active bodies, the activity in some cases being due to the glucoside itself and in others to the decomposition products of the glucoside. *Glucosidal drugs* are drugs that contain glucosides and it is difficult to extract and isolate the glucosides in them without having the glucosides split up into something different. Owing to the difficulty in extracting and isolating the glucosides contained in glucosidal drugs they cannot be assayed by chemical means. Biological assays (determining the strength by testing the drug on an animal) have been provided for certain glucosidal drugs, as digitalis, strophanthus, and squill. Glucosidal drugs are sometimes grouped according to their therapeutic action as drugs containing: Sweet glucosides, bitter glucosides, glucosides acting on the heart, purgative glucosides, astringent glucosides, and saponin.

Digitalis, Digitalis (Foxglove), U. S. P.—The dried leaf of *Digitalis purpurea.* The potency of Digitalis shall be such that 0.1 Gm. of it, when assayed as directed, shall possess an activity equivalent to not less than 1 U. S. P. digitalis unit. One *United States Pharmacopoeial Digitalis Unit* is identical in potency with the *International Digitalis Unit*, as adopted in 1928 by the Permanent Commission on Biological Standardization of the Health Organization of the League of Nations. One *International Digitalis Unit* represents the activity of 0.1 Gm. of the "International Standard Digitalis Powder." Digitalis contains a number of glucosides, those of the greatest importance being digitalin, digitonin, digitalein, and digitoxin. There are many proprietary preparations of Digitalis on the market but the U. S. P. recognizes only two, Powdered Digitalis and Tincture of Digitalis. Tincture of Digitalis is on the Supply Table. The potency of Powdered Digitalis is the same as Digitalis and when Digitalis is prescribed Powdered Digitalis should be dispensed. *Digitalis should be stored in waterproof and airtight containers and protected from light.*

Action and Uses: It is used as a cardiac tonic and stimulant, slowing and strengthening the heart beat. Digitalis is cumulative in the system. Evidence of accumulation is shown by headache, giddiness, sickness, and a marked slowing of the pulse. The active principles of Digitalis are irritating to the gastric mucous mebranes and may cause nausea and vomiting. In case of mild poisoning or overdosing administer atropine sulfate hypodermically. The diuretic effect of Digitalis is due to improved circulation.

Average dose: 0.1 Gm. or 1½ grains.

Tinctura Digitalis, Tincture of Digitalis, U. S. P.—The potency of Tincture of Digitalis shall be such that 1 cc of the tincture, when assayed as directed, shall possess an activity equivalent to not less than 1 and not more than 1.1 U. S. P. Digitalis Units. It is a 10 per cent tincture, which means that 100 cc of tincture possesses the medicinal activity of 10 Gm. of the powdered drug. The alcoholic content of the tincture is 67 to 72 per cent by volume. Preserve the tincture in small, well-closed bottles, protected from light, and in a cool place.

Action and Uses: *See* Digitalis.

Average dose: 1 cc or 15 minims.

Strophanthus, Strophanthus, N. F.—The dried ripe seed of *Strophanthus Kombe*, or of *Strophanthus hispidus*, deprived of the awns. When assayed biologically as prescribed it possesses a potency, per gram, equivalent to not less than 55 milligrams of standard ouabain, U. S. P. XI. (Ouabain is a glucoside obtained from *Acokanthera Ouabaio* or from *Strophanthus gratus* that is twice as toxic as Strophanthin, and is used for the international control of Strophanthin preparations.) Strophanthus contains the active glucoside Strophanthin which is on the Supply Table.

Action and Uses: *See* Strophanthin.

Strophanthinum, Strophanthin, U. S. P.—A glucoside or mixture of glucosides obtained from *Strophanthus Kombe.* Strophanthin, when assayed as directed, shall possess a potency equivalent to the activity of not less than 40 per cent and not more than 60 per cent of ouabain when similarly assayed. Preserve it in well-closed containers and protected from light.

Action and Uses: *It is extremely poisonous.* Its action is similar to the action of digitalis. It is absorbed more rapidly, its action is faster, and it is used in place of digitalis when immediate effect is required. In case of poisoning give inhalations of chloroform to quiet the heart. If the poison is in the stomach it should be washed out. Death occurs quickly from poisoning.

Average dose: 0.0006 Gm. or 1/100 grain.

Santoninum, Santonin, U. S. P.—The inner anhydride of santoninic acid, obtained from several species of *Artemisia*. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs in colorless crystals, usually tabular, or as a white, crystalline powder; odorless and nearly tasteless at first, but afterwards developing a bitter taste; stable in the air, but becoming yellow on exposure to light. It is very slightly soluble in water and soluble in 43 parts of alcohol.

ACTION AND USES: It is used principally as an anthelmintic for the removal from the intestine of *Ascaris lumbricoides* (round worms). It makes objects appear to the patient as if viewed through a yellow glass (xanthopsia).

Average dose: 0.06 Gm. or 1 grain. (It is on the Supply Table in one-half grain tablets.)

Tinctura Gentianæ Composita, Compound Tincture of Gentian, U. S. P.—It contains in 1,000 cc the glycerin-hydro-alcoholic soluble principles from 100 Gm. of gentian, the active principle of which is the glucoside gentiopicrin, 40 Gm. of bitter orange peel, and 10 Gm. of cardamom seed.

ACTION AND USES: It is used as a bitter tonic.

Average dose: 4 cc or 1 fluidram.

Drugs containing cathartic principles and their preparations.

Fluidextractum Rhei, Fluidextract of Rhubarb, N. F.—Made by extracting the active principles of rhubarb with a menstruum consisting of 4 volumes of alcohol and 1 volume of water.

ACTION AND USES: Acts principally on the large intestine by producing frequent fluid stools accompanied by griping. The stools frequently are colored yellow with bile. On account of the rheotannic acid which it contains, rhubarb constipates after its purgative action. As a laxative it is particularly efficient in treating summer diarrhœas of children, because after its purgative effect has been produced it checks the diarrhœa.

Average dose: 1 cc or 15 minims.

Extractum Cascaræ Sagradæ, Extract of Cascara Sagrada, U. S. P.—It is an extract obtained from cascara sagrada. One grain of extract represents 3 Gm. of cascara sagrada. Cascara sagrada is the dried bark of the trunk and branches of *Rhamnus Purshiana*. Unlike most extracts, it is made by exhausting the drug with boiling water.

ACTION AND USES: It is a valuable laxative, acting mainly on the lower bowel. It is used in the treatment of chronic constipation. It is supplied to the Navy in tablet form.

Average dose: 0.25 Gm. or 4 grains.

Fluidextractum Cascaræ Sagradæ Aromaticum, Aromatic Fluidextract of Cascara Sagrada, U. S. P.—Made by extracting the active principles of cascara sagrada with boiling water. The bitter taste is removed from the cascara by maceration and percolation while it is mixed with magnesium oxide. It is aromatized and sweetened with pure extract of glycyrrhiza, saccharin, oil of anise, oil of coriander, and methyl salicylate. It contains from 17 to 19 per cent alcohol.

ACTION AND USES: It is preferred as a laxative over the other preparation of cascara because of its pleasant taste.

Average dose: 2 cc or 30 minims.

Products obtained from animal substances.

Many products of great value in the prevention and treatment of disease are obtained from animals, whole animals, animal organs, animal excretions,

and animal serum being used in their production. Most of the animal products used in medicine are of such complex composition that they cannot be classed as definite chemicals; two, however, pepsin and pancreatin, are classed as animal proteins, and lactic acid, obtained from milk, has a definite chemical formula.

From whole animals are obtained Cantharides and Cochineal, U. S. P.; from animal organs are obtained Thyroid, Solution of Parathyroid, Thyroxin, Solution of Posterior Pituitary, Epinephrine, Liver Extract, U. S. P., and others; from animal excretions are obtained Oxgall, U. S. P. and Milk, N. F.; and from animal serums are obtained Serums, Vaccines, Anti-toxins, Toxins, etc. Animal fats and oils have been described elsewhere but lack of space prevents the description here of all but a few of the remaining products obtained from animals and the student is referred to the U. S. Pharmacopœia, textbooks on the Practice of Pharmacy, and other textbooks for information concerning them.

Pepsinum, Pepsin, U. S. P.—A substance containing a proteolytic ferment or enzyme obtained from the glandular layer of the fresh stomach of the hog. When assayed as directed, it digests not less than 3,000 and not more than 3,500 times its weight of egg albumin. Pepsin of higher digestive power may be reduced to the official standard by admixture with pepsin of lower digestive power or with lactose (sugar of milk). Preserve it in well-closed containers in a cool place.

PROPERTIES: It occurs in lustrous, transparent or translucent scales, granular or spongy masses, ranging in color from light yellow to light brown, or as a fine, white or cream-colored amorphous powder, free from any offensive odor, and having a slightly acid or saline taste. It is not more than slightly hygroscopic, is freely soluble in water and nearly insoluble in alcohol, in chloroform, and in ether. When in solution it is incompatible with alkalies, alkali earths, and alkali carbonates. It is destroyed by salts of copper, lead, silver, mercury, bismuth, etc. The presence of more than 0.5 per cent of hydrochloric acid in pepsin solution retards its proteolytic activity.

ACTION AND USES: Pepsin is a normal constituent of the gastric juice and its function is to digest albuminous matter. It is given when there is a deficiency of pepsin in the gastric juice. There are a large number of National Formulary elixirs and liquids containing pepsin. *Pepsin and pancreatin never should be administered together; nor should pepsin be administered with sodium bicarbonate which renders it inert.*

Average dose: 0.5 Gm. or 8 grains.

Liquor Pituitarii Posterioris, Solution of Posterior Pituitary (Solution of Pituitary), U. S. P.—It contains the water-soluble principles from the fresh posterior lobe of the pituitary body of healthy domesticated animals used for food by man. The pituitary body must have been removed from the animal immediately after slaughtering, and then extracted at once or kept frozen until extracted. One cc of Solution of Posterior Pituitary produces an activity upon the isolated uterus of the virgin guinea pig, corresponding to not less than 80 per cent and not more than 120 per cent of that produced by 0.005 Gm. of the Standard Powdered Posterior Pituitary. The solution must be sterile. Preserve it in small, well-filled, amber-colored containers or in ampules.

PROPERTIES: A transparent liquid, colorless, or nearly so, having a faint, characteristic odor.

ACTION AND USES: It is administered hypodermically, or intramuscularly. It stimulates smooth muscle, especially that of the blood vessels and the uterus. It increases blood pressure and is given in certain conditions of surgical shock. It is used principally to stimulate uterine contractions in labor. It is not effective when given by mouth.

Average dose: 1 cc or 15 minims.

Liquor Epinephrinæ Hydrochloridi, Solution of Epinephrine Hydrochloride, U. S. P.—It is a solution (1–1,000) of epinephrine in distilled water and hydrochloric acid, containing, in each 100 cc, not less than 0.095 Gm. and not more than 0.105 Gm. of epinephrine ($C_9H_{13}O_3N$). Epinephrine is sensitive to oxidizing agents and should be bottled excluding air. Once the bottle has been opened deterioration takes place rapidly. The solution should be slightly acid, should contain a preservative to prevent the growth of germs and fungi, and should contain a reducing agent to prevent oxidation. It is commonly called adrenalin.

PROPERTIES: A nearly colorless, slightly acid liquid, gradually turning dark on exposure to air and light. When the solution has become brown in color, or contains a precipitate, it must be rejected. Preserve it in small, well-filled, amber-colored bottles or in ampules.

ACTION AND USES: It is used locally for its vaso-constrictor action in hæmorrhage. The vaso-constrictor action is used to prolong the anæsthetic effect of local anæsthetics by retarding the circulation in the injected area, thus hindering removal of the anæsthetic agent by too rapid absorption into the blood stream. In this way it also lessens the general toxic effect of the anæsthetic. Intravenous injections are given in shock and anæsthetic accidents. By constricting the blood vessels it causes a rise in blood pressure. It stimulates the heart.

Average dose: 0.5 cc or 8 minims by parenteral injection.

Extractum Hepatis, Extract of Liver (Dry Liver Extract), U. S. P.—Contains that soluble fraction of mammalian livers which increases the number of red blood cells in the blood of persons suffering from pernicious anæmia. This fraction, which has been dried, conforms to the specifications for Standardization of Products for the Treatment of Pernicious Anæmia, U. S. P. XI, approved by the "U. S. P. Anti-anæmia Preparations Advisory Board." Preserve it in well-closed containers, preferably in a cool place.

PREPARATION: No official method of preparation is prescribed by the U. S. P. In the method of Doctors Minot and Murphy of Boston, Mass., livers of food animals are ground with water, the mixture adjusted to the isoelectric point, heated to coagulate the protein and filtered; the filtrate is evaporated *in vacuo* and enough alcohol added to cause a concentration of 70 per cent of ethyl alcohol. The consequent precipitate is separated, dried, and powdered.

PROPERTIES: It is a yellow powder with a not unpleasant taste, and almost completely soluble in water, but insoluble in alcohol, acetone, and ether.

ACTION AND USES: It is used in pernicious anæmia, in sprue when the bone marrow is not exhausted, and in certain cases of obscure anæmia. Although used experimentally in other conditions only those preparations of liver primarily intended for the treatment of pernicious anæmia have thus far been accepted by the Council on Pharmacy and Chemistry of the American Medical Association. *Liquor Hepatis, Solution of Liver,* and *Liquor Hepatis Purificatus, Purified Solution of Liver* are also official in the U. S. P.

Average dose: As indicated on the label of the container.

Insulin, N. N. R.—An aqueous solution of an active principle from the pancreas which affects sugar metabolism. The strength of Insulin is expressed in "units." The unit is equivalent to 0.125 milligrams of the International Standard Preparation of Dry Insulin Hydrochloride prepared by the Medical Council of Great Britain. One milligram of this standard preparation contains 8 insulin units, as provisionally defined by the Insulin Commission of the University of Toronto, Canada.

ACTION AND USES: It is used in the treatment of diabetes. If a suitable dose of Insulin is administered at suitable intervals to a person suffering from

diabetes mellitus, the blood sugar is maintained at or near a normal level and the urine remains free from sugar. In case of overdosing with Insulin the patient complains of weakness and fatigue and a feeling of nervousness and tremulousness followed by profuse sweating. This condition is relieved by giving orange juice by mouth, or dextrose intravenously if the patient is comatose. Insulin is administered by injection into the loose subcutaneous tissue of the body about 30 minutes before meals. There is no average dose for Insulin, each case must be studied individually. The dose of Insulin should always be expressed in units rather than by cubic centimeters.

Alkaloids, alkaloidal salts, and alkaloidal drugs.

Alkaloids are physiologically active principles found in the vegetable kingdom or produced synthetically having a complex composition. They are all nitrogenous and in addition contain carbon, hydrogen, and generally oxygen. Because they contain nitrogen, are built on the ammonia type of bases, and act as ammonias in their method of forming salts, they frequently are spoken of as nitrogenous plant bases. They are derivatives principally of pyridine, quinoline, or similar ringed bodies. The term alkaloid means "like an alkali," with which substances, however, they must not be confused. Substances reacting to many of the alkaloidal tests are obtained from the animal kingdom, those found in living animal tissues being generally known as *leucomaines* while those found in decayed animal tissues (probably produced in the process of decay) are known as *ptomaines* or "cadaveric alkaloids." Alkaloids are regarded as decomposition products of proteins, nucleins, etc., in the plant cells during the process of growth, which have condensed with the substances present in plants.

In the vegetable kingdom their occurrence is confined to a few plant families as follows: Apocynaceæ, Leguminosæ, Liliaceæ, Loganiaceæ, Papaveraceæ, Ranunculaceæ, Rubiaceæ, Rutaceæ, Solanaceæ, and Umbelliferæ. They exist in all parts of plants, usually in the form of salts, as tannates, malates, quinates, meconates, etc. They can be extracted from drugs containing them, and are the active principles of the drugs in which they are present.

Some alkaloids are solids (amides), and some are liquids (amines). Most of the nonvolatile alkaloids are solid, the volatile ones are mainly liquid and some of them contain no oxygen. They are generally colorless, are alkaline in their reaction, and resemble inorganic bases, especially ammonia, in their chemical behavior, in that they combine directly with acids to form salts. Their basic properties vary in intensity; some are strongly alkaline, and others are very weak. They are nearly all poisonous and have a bitter taste. With a few exceptions they are insoluble in water, but are soluble in alcohol, ether, chloroform, and petroleum benzine. The solubility of their salts is the reverse, being soluble in water but insoluble or slightly soluble in alcohol and insoluble in chloroform, ether, and petroleum benzine. Most of them are precipitated in aqueous solution from their salts upon the addition of alkalies or agents having an alkaline reaction. The alkaloids are decomposed by strong reducing or oxidizing agents (reason for the use of potassium permanganate in morphine poisoning). They are precipitated from their aqueous solution by mercuric potassium iodide, gold chloride, picric acid, tannic acid, sodium hydroxide, potassium hydroxide, alkali carbonates, alkali salicylates, benzoates, iodides, and bromides.

They vary greatly in their action on the system; some are stimulants, while others are depressants, etc. Some of the most valuable remedies used in medicine, as well as most of the narcotic habit-forming drugs, belong to this class. It is important to differentiate between alkaloids, alkaloidal salts, and

alkaloidal drugs. Alkaloids are the basic substances; morphine is an alkaloid. Alkaloidal salts are compounds (salts or esters) formed by the union of the basic alkaloid with an acid; morphine sulfate is an alkaloidal salt formed by the union of morphine with sulfuric acid. Alkaloidal drugs are drugs (parts of plants) containing alkaloids; opium is an alkaloidal drug because it contains, among others, the alkaloid morphine; cinchona is an alkaloidal drug because one of the alkaloids it contains is quinine.

In order to distinguish alkaloids from glucosides a different terminology, which has been carried in the Pharmacopœial nomenclature, has been adopted for each class. The ending *ine* (Latin *ina*) is applied to alkaloids, and the ending *in* (Latin *inum*)) is given to glucosides.

Opium, Opium, U. S. P.—The air-dried milky exudation obtained by incising the unripe capsules of *Papaver somniferum* or its variety *album*, and yielding in its normal condition not less than 9.5 per cent of anhydrous morphine. This form of opium is not used medicinally nor is it on the Supply Table, but it is used in making powdered opium and granulated opium, and these two preparations of opium are used in making the other opium preparations. *Opium, its preparations, and its derivatives are restricted in their sale and use by the Harrison Narcotic Act*, as they are habit-forming drugs.

Opium Pulveratum, Powdered Opium, U. S. P.—Opium dried at a temperature not exceeding 70° C., reduced to a very fine powder, and yielding not less than 10 per cent nor more than 10.5 per cent of anhydrous morphine. Powdered opium of a higher morphine percentage may be brought within the required limits by admixture with powdered opium of a lower percentage, or with some inert diluent. Preserve it in well-closed containers.

PROPERTIES: It is a yellowish-brown to brownish-red powder, having a heavy, characteristic odor and a very bitter, characteristic taste.

CONSTITUENTS: Opium contains more than 20 different alkaloids, the most important of which are morphine and codeine.

ACTION AND USES: Opium and its preparations when given internally are depressant to the central nervous system, analgesic, and constipating. Opium has no local effect other than that produced after absorption. The effects produced by opium preparations are due principally to morphine.

Average dose: 0.06 Gm. or 1 grain.

Pulvis Ipecacuanhæ et Opii, Powder of Ipecac and Opium (Dover's Powder), U. S. P.—It is made by mixing 10 per cent opium powder, 10 per cent ipecac powder, and 80 per cent sugar of milk. Ten grains of this powder contains 1 grain of powdered opium, 1 grain of powdered ipecac, and 8 grains of milk sugar.

ACTION AND USES: It is used as an anodyne and diaphoretic.

Average dose: 0.5 Gm. or 8 grains.

Tinctura Opii, Tincture of Opium (Laudanum), U. S. P.—One hundred cc of tincture of opium yields not less than 0.95 Gm. nor more than 1.05 Gm. of anhydrous morphine. It is made by extracting the active principles from granulated opium with distilled water and alcohol.

ACTION AND USES: It is a convenient form for the administration of opium. It is used in the preparation of Lead and Opium Wash, N. F. It is given in diarrhœa for its sedative and constipating effect on the intestinal tract. It produces the characteristic effects of opium when given internally, relieving pain and producing sleep.

Average dose: 0.6 cc or 10 minims.

Tinctura Opii Camphorata, Camphorated Tincture of Opium (Paregoric), U. S. P.—It is made of 40 cc of Tincture of Opium, 4 cc of Oil of Anise, 4 Gm. of Benzoic Acid, and 4 Gm. of Camphor dissolved in 900 cc of diluted alcohol to

which 40 cc of glycerin and sufficient diluted alcohol are added to make the finished product measure 1,000 cc. It is the weakest and one of the most used of the opium preparations and yields, from each 100 cc, not less than 0.035 Gm. and not more than 0.045 Gm. of anhydrous morphine.

ACTION AND USES: It possesses analgesic and carminative properties. It is one of the ingredients in Brown Mixture (checks cough). It is used to relieve abdominal pain due to flatus (gas in the intestine), to check diarrhœa, etc.

Average dose: 4 cc or 1 fluidram.

Morphinæ Sulfas, Morphine Sulfate, U. S. P.—The sulfate of the alkaloid morphine. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs in white, feathery, silky crystals, or cubical masses of crystals, or a white crystalline powder, odorless, and permanent in the air. It is soluble in 15.5 parts of water and in 565 parts of alcohol.

ACTION AND USES: It is a powerful narcotic. It is depressant to the central nervous system, relieves pain, produces sleep, and tends to cause constipation. It is a dangerous habit-forming drug and should never be prescribed in repeated doses except by a doctor. *In case of acute poisoning by morphine, wash out the stomach with potassium permanganate solution and give stimulants.*

Average dose: 0.008 Gm. or ⅛ grain.

Codeina, Codeine (Methylmorphine), U. S. P.—An alkaloid obtained from opium, or prepared from morphine by methylation. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs in colorless crystals or as a white, crystalline powder; odorless, and is slowly efflorescent in dry air. It is soluble in 120 parts of water and 2 parts of alcohol. Its aqueous solution is alkaline to litmus.

ACTION AND USES: It is sedative, analgesic, and hypnotic. Its action is somewhat like that of morphine but less intense. It is largely used as a sedative, in the treatment of coughs, to lessen the irritation of the respiratory tract.

Average dose: 0.03 Gm. or ½ grain.

Codeinæ Sulfas, Codeine Sulfate, U. S. P.—The sulfate of the alkaloid codeine. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs in colorless crystals, usually needle-like, or as a white crystalline powder, efflorescent in the air. It is soluble in 30 parts of water and very slightly soluble in alcohol.

ACTIONS AND USES: Same as codeine.

Average dose: 0.03 Gm. or ½ grain.

Apomorphinæ Hydrochloridum, Apomorphine Hydrochloride, U. S. P.—The hydrochloride of an alkaloid prepared from morphine. Preserve it, protected from light, in small, well-stoppered vials which previously have been rinsed with diluted hydrochloric acid and dried. Apomorphine hydrochloride, if it imparts at once an emerald-green color to 100 parts of distilled water when shaken with it in a test tube, is unfit for use.

PROPERTIES: It occurs in minute, white or grayish-white, glistening crystals; odorless, and acquiring a greenish tint upon exposure to light and air. It is soluble in 50 parts of water and in 50 parts of alcohol.

ACTION AND USES: It is an emetic and expectorant, and is devoid of narcotic properties. Its principal use is as an emetic in cases where the stomach tube cannot be passed or emetics cannot be given by mouth. It is administered hypodermically.

Average dose: Emetic, hypodermically, 0.005 to 0.0065 Gm. or 1⁄12 to 1⁄10 grain.

Cinchona, Cinchona (Peruvian Bark), U. S. P.—The dried bark of the stem or root of *Cinchona succirubra*, or of its hybrids, yielding not less than 5 per cent

of the alkaloids of cinchona. The cinchona tree grows along the Andes Mountains in South America. Cinchona is not on the Supply Table, but it is the source of quinine, and is used in making compound tincture of cinchona.

Tinctura Cinchonæ Composita, Compound Tincture of Cinchona, U. S. P.—One hundred cc of compound tincture of cinchona yields not less than 0.4 Gm. nor more than 0.5 Gm. of the alkaloids of cinchona.

PREPARATION: It is made by extracting 100 Gm. of Cinchona; 80 Gm. Bitter Orange Peel, and 20 Gm. of Serpentaria with a menstruum composed of alcohol, water, and glycerin and collecting 1,000 cc of percolate. *See* U. S. P.

ACTION AND USES: It is a valuable bitter tonic and antimalarial.

Average dose: 4 cc or 1 fluidram.

Quininæ Sulfas, Quinine Sulfate, U. S. P.—The sulfate of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs in white, fine, needle-like crystals, usually lusterless, making a very light and easily compressible mass; odorless and having a persistent, very bitter taste. It is soluble in 810 parts of water, and 120 parts of alcohol. It is freely soluble in water to which has been added a small amount of diluted hydrochloric or sulfuric acid.

ACTION AND USES: It is *antimalarial,* antipyretic, and a bitter tonic. It is used principally in the treatment of malaria, for which it is specific. It should be noted that quinine sulfate is practically insoluble in water. If an aqueous solution is desired, it may be made by adding to the quinine sulfate mixed with the water in a graduate, diluted sulfuric or hydrochloric acid drop by drop until a solution is produced. An acid salt is formed in solution which is very soluble in water.

Average dose: Tonic, 0.1 Gm. or 1½ grains; antimalarial, at least 1 Gm. or 15 grains daily.

Quininæ Hydrochloridum, Quinine Hydrochloride, N. F.—The hydrochloride of the alkaloid quinine. Preserve it in well-closed containers.

PROPERTIES: It occurs in white, silky, glistening needles, odorless, and having a very bitter taste. It is soluble in 16 parts of water (more soluble than the sulfate), 0.8 part of alcohol, and in 7 parts of glycerin.

ACTION AND USES: The action and use of quinine hydrochloride is the same as the sulfate. It was added to the Supply Table for use in making Elixir of Iron, Quinine, and Strychnine, N. F., because it is more soluble than the sulfate.

Average dose: Tonic, 0.1 Gm. or 1½ grains; antimalarial, 1 Gm. or 15 grains daily.

Belladonnæ Folium, Belladonna Leaf (Deadly Nightshade), U. S. P.—The dried leaves and tops of *Atropa belladonna,* yielding not less than 0.3 per cent of the total alkaloids of belladonna leaves. Belladonna leaves are not supplied to the Navy but they are used in making extract of belladonna and are the source of atropine. Belladonna leaves contain the mydriatic (pupil dilating) alkaloids of atropine, hyoscyamine, and belladonnine.

ACTION AND USES: *See* the Extract.

Average dose: 0.06 Gm. or 1 grain.

Extractum Belladonnæ, Extract of Belladonna, U. S. P.—Extract of belladonna yields, from each 100 Gm., not less than 1.18 Gm. nor more than 1.32 Gm. of the alkaloids of belladonna leaf. It is dark green in color and of a pilular consistence. Extract of belladonna may be used in making tincture of belladonna. It is used in making belladonna plaster and belladonna ointment.

ACTION AND USES: It is used internally as an anodyne and antispasmodic. In large doses it produces dryness of the throat, dilates the pupils, diminishes the secretion of urine, causes difficulty in swallowing, and checks perspiration.

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It prevents griping of the intestine and is used in the compound laxative pill for this purpose. It is used locally in plasters, ointments, and suppositories for its anodyne effect.

Average dose: 0.015 Gm. or ¼ grain.

Atropinæ Sulfas, Atropine Sulfate, U. S. P.—The sulfate of the alkaloid atropine.

PROPERTIES: It occurs as a white, crystalline powder or colorless crystals efflorescent in dry air. *Great caution should be used in tasting it, and then only in very dilute solution.* It is soluble in 0.4 parts of water, and 5 parts of alcohol.

ACTION AND USES: It is used in 0.5 per cent solution to dilate the pupil of the eye. CAUTION: *It is an extremely poisonous drug.*

Average dose: 0.0005 Gm. or 1/120 grain.

Homatropinæ Hydrobromidum, Homatropine Hydrobromide, U. S. P.—The hydrobromide of homatropine, an alkaloid obtained by the condensation of tropine and mandelic acid. Preserve it in well-closed containers, protected from light. It is an artificial alkaloid (synthetic).

PROPERTIES: It occurs as a white, crystalline powder or colorless crystals. *Great caution must be observed in tasting it, using only very dilute solutions. Homatropine hydrobromide is extremely poisonous.* It is soluble in 6 parts of water and 40 cc of alcohol.

ACTION AND USES: The action of homatropine is nearly identical with that of atropine. A 1 per cent solution instilled into the eye produces dilatation of the pupil in less than an hour, and the effect wears off within 48 hours. This property gives it a decided advantage over atropine, which requires a longer time to dilate the pupil and a much longer time to recover from its effect.

Average dose: 0.0005 Gm. or 1/120 grain (seldom used internally).

Hyoscyamus, Hyoscaymus (Henbane), U. S. P.—The dried leaves, with or without tops, of *Hyoscyamus niger*, yielding not less than 0.040 per cent of the alkaloids of hyoscyamus. Hyoscyamus is not on the Supply Table but it is used in making the fluidextract of hyoscyamus, and it is one of the sources of scopolamine (hyoscine). The alkaloids contained in hyoscyamus are hyoscyamine and hyoscine (scopolamine).

ACTION AND USES: It is related closely to belladonna in its action, but is more sedative to the nervous system (due to the hyoscine which it contains). Hyoscyamus is supplied to the Navy in the form of a fluidextract, and its active principle hyosine is supplied in hypodermic tablets under the name scopolamine hydrobromide.

Average dose: 0.2 Gm. or 3 grains.

Fluidextractum Hyoscayamus, Fluidextract of Hyoscyamus (Fluidextract of Henbane), N. F.—One hundred cc of fluidextract of hyoscyamus yields not less than 0.035 nor more than 0.045 Gm. of the alkaloids of hyoscyamus.

ACTION AND USES: It is used as a hypnotic, nervous sedative, and analgesic. Given with purgatives it prevents griping effect.

Average dose: 0.2 cc or 3 minims.

Scopolaminæ Hydrobromidum, Scopolamine Hydrobromide (Hyoscine Hydrobromide), U. S. P.—The hydrobromide of levorotatory scopolamine, also known as hyoscine, obtained from various plants of the *Solanaceæ*. Preserve it in well-closed containers protected from the light.

PROPERTIES: It occurs in colorless crystals or a white, granular powder, odorless, slightly efflorescent. *Great caution must be observed in tasting it and then only in very dilute solutions, as it is extremely poisonous.* It is soluble in 1.5 parts of water and 20 parts of alcohol.

ACTION AND USES: It is a powerful cerebral and spinal sedative and hypnotic. It is given to produce sleep, in cases of mania.

Average dose: 0.0003 Gm. or 1/200 grain.

Nux Vomica, Nux Vomica, U. S. P.—The dried ripe seed of *Strychnos Nux Vomica*, an Asiatic plant. The alkaloids contained in nux vomica are strychnine and brucine. It is not on the Supply Table but is used in the preparation of tincture of nux vomica.

ACTION AND USES: The action of nux vomica is the same as that of strychnine, which is its most active principle. It is a direct stimulant to the spinal cord, and indirectly a stimulant to nearly all the organs of the body, thereby acting as a tonic. *In large doses it is a poison*, producing overstimulation and convulsions. Chloroform inhalations and chloral hydrate internally are given to relieve the convulsions.

Average dose: 0.1 Gm. or 1½ grains.

Tinctura Nucis Vomicæ, Tincture of Nux Vomica, U. S. P.—One hundred cc of tincture of nux vomica yields not less than 0.108 Gm. nor more than 0.120 Gm. of strychnine. It is approximately a 10 per cent tincture, but the exact strength is based on its proximate assay.

ACTION AND USES: It possesses the stimulating and tonic properties of nux vomica. It is used as a gastro-intestinal tonic.

Average dose: 0.5 cc or 8 minims, which is equivalent to about 1/120 grain of strychnine.

Strychninæ Sulfas, Strychnine Sulfate, U. S. P.—The sulfate of the alkaloid strychnine. Preserve it in well-closed containers, protected from light.

PROPERTIES: It occurs in colorless or white crystals, or as a white crystalline powder; odorless, efflorescent in dry air, and having an intensely bitter taste. It is soluble in 35 parts of water and 81 parts of alcohol. *Great caution must be used in tasting it, and then only in very dilute solutions, as it is extremely poisonous.*

ACTION AND USES: It is a powerful stimulant directly to the spinal cord and indirectly to nearly all the organs of the body. *It is a powerful neurotic poison, and must be administered cautiously.* It is used as a respiratory and circulatory stimulant, is used also as a bitter tonic, and frequently is combined with iron and quinine in tonics, elixirs, and tablets.

Average dose: 0.002 Gm. or 1/30 grain.

Physostigminæ Sulfas, Physostigmine Sulfate (Eserine Sulfate), Unofficial.—The sulfate of an alkaloid obtained from *Physostigma venonosum*. Preserve it in small, sealed containers, protected from light.

PROPERTIES: It occurs in minute white crystals, becoming yellow on exposure to light and air. It is very deliquescent and readily soluble in water.

ACTION AND USES: It is a myotic and is used in the treatment of eye diseases for the purpose of contracting the pupil. It is used in glaucoma to lessen intra-ocular pressure. It may be used to hasten recovery from the effects of mydriatics. For use in the eye a 2 per cent boric-acid solution should be used as the solvent. Boric acid prevents physostigmine solution from turning red in color. A red-colored solution should not be used.

Average dose: 0.001 Gm. or 1/60 grain.

Pilocarpus, Pilocarpus (Jaborandi), Unofficial.—The dried leaflets of *Pilocarpus Jaborandi* yielding not less than 0.6 per cent of the alkaloids of Pilocarpus. It contains a number of alkaloids, the most important of which is pilocarpine. Pilocarpine hydrochloride is on the Supply Table in the form of 0.008 Gm. or ⅛ grain hypodermic tablets.

Pilocarpinæ Hydrochloridum, Pilocarpine Hydrochloride, N. F.—The hydrochloride of an alkaloid obtained from the dried leaflets of *Pilocarpus Jaborandi.* Preserve it in well-closed containers protected from light.

PROPERTIES: It occurs in colorless, translucent crystals, odorless, and having a faintly bitter taste; hygroscopic on exposure to the air. It is soluble in 0.3 parts of water.

ACTION AND USES: It is used as a diaphoretic. In diseases of the eye such as glaucoma and corneal ulcer pilocarpine is used locally in weak solution to contract the pupil of the eye and thereby reduce intra-ocular pressure.

Average dose: 0.005 Gm. or 1/12 grain (hypodermically).

Aconitum, Aconite (Monkshood), U. S. P.—The dried tuberous root of *Aconitum Napellus* and its subspecies and varieties containing aconitine, a very active and poisonous alkaloid. Aconite is not on the Supply Table but is used in making tincture of aconite.

Tincture Aconiti, Tincture of Aconite, U. S. P.—It is approximately a 10 per cent tincture. Tincture of Aconite possesses a potency, per cubic centimeter, equivalent to not less than 0.140 milligram and not more than 0.160 milligram of the alkaloid aconitine.

ACTION AND USES: Aconite slows the pulse and lowers the blood pressure It is used internally as a circulatory depressant, diaphoretic, and antipyretic in fevers of short duration. *It is a very poisonous tincture and must be administered cautiously.*

Average dose: 0.6 cc or 10 minims.

Ipecacuanha, Ipecac, U. S. P.—The dried rhizome and roots of *Cephaëlis Ipecacuanha* or of *Cephaëlis acuminata*, yielding not less than 2 per cent of the ether-soluble alkaloids of ipecac. Ipecac contains several alkaloids, the most important of which is emetine.

ACTION AND USES: In large doses it acts as an emetic partly through its local irritant action. In small doses it stimulates the secretions of the respiratory tract. It is specific against amœbic dysentery, given in the form of enteric pills.

Average dose: Expectorant, 0.06 Gm. or 1 grain; emetic, 1 Gm. or 15 grains.

Fluidextractum Ipecacuanhæ, Fluidextract of Ipecac, U. S. P.—One hundred cc of fluidextract of ipecac yields not less than 1.8 Gm. nor more than 2.2 Gm. of the ether-soluble alkaloids of ipecac.

ACTION AND USE: The action and use of the fluidextract is the same as that of powdered ipecac. The principal use of the fluidextract is in making the syrup of ipecac.

Average dose: Expectorant, 0.05 cc or 1 minim; emetic, 1 cc or 15 minims.

Emetinæ Hydrochloridum, Emetine Hydrochloride, U. S. P.—The hydrochloride of an alkaloid obtained from ipecac or prepared synthetically. It contains variable amounts of water of crystallization. Preserve it in well-closed containers protected from light.

PROPERTIES: It occurs as a white crystalline powder, without odor, and freely soluble in water.

ACTION AND USES: It is used in the treatment of pyorrhœa and amœbic dysentery, administered hypodermically.

Average dose: 0.02 Gm. or 1/3 grain.

Coca, Coca, Unofficial.—The dried leaves of *Erythroxylon Coca*, known commercially as *Huanuco Coca*, or as *Truxillo Coca*, yielding not less than 0.5 per cent of the ether-soluble alkaloids of coca. It is cultivated in South America, Mexico, and the West Indies. Most of the coca leaves come from Peru, Bolivia, and Ecuador. It contains a number of alkaloids, the most important of which

is cocaine. *Coca leaves, its preparations, and derivatives, which includes cocaine, are restricted in their sale and use by the Harrison Narcotic Act.* Coca leaves are not on the Supply Table nor are they recognized by the Pharmacopœia or National Formulary, and are of interest only as the source of cocaine.

Cocainæ Hydrochloridum, Cocaine Hydrochloride, U. S. P.—The hydrochloride of the alkaloid cocaine, obtained from *Coca* leaves.

Properties: It occurs in colorless crystals or as a white, crystalline powder; soluble in 0.4 cc of water; soluble in glycerin and slightly so in alcohol. Cocaine solutions are decomposed by the heat of boiling water or in the presence of even slight traces of alkali.

Action and Uses: When applied locally, cocaine paralyzes the peripheral nerves, causing loss of sensation. When injected around a nerve sheath or into a nerve it produces anæsthesia in the area supplied by the sensory fibers. of that nerve. When absorbed into the system it first produces stimulation, followed by depression of the central nervous system. The principal use of cocaine is as a local anæsthetic. It can be used for deadening sensation in the eye when foreign bodies are to be removed. It is employed in solutions ranging from 1 to 5 per cent, made with distilled water. The absorption of cocaine is largely prevented by mixing 1 part of solution of epinephrine hydrochloride with 20 parts of cocaine solution. Cocaine is a dangerous habit-forming drug and must be used cautiously to avoid starting the habit.

Average dose: 0.015 Gm. or ¼ grain.

Ergota, Ergot (Ergot of Rye), U. S. P.—The dried sclerotium of *Claviceps purpurea* developed on rye plants. It contains not more than 8 per cent of moisture and not more than 4 per cent of seeds, fruits, and other foreign organic matter. Ergot is not on the Supply Table but is used in making the Fluidextract of Ergot.

Fluidextractum Ergotæ, Fluidextract of Ergot, U. S. P.

Action and Uses: It is a powerful vascoconstrictor. It is used in the latter stages of labor as a stimulant to the uterus and a preventive of hæmorrhage. Is also used to control other internal hæmorrhages and for the relief of chronic congestions. Owing to its effect on the circulation it is also employed in many other diseases.

Average dose: 2 cc or 30 minims.

Caffeina Citrata, Citrated Caffeine, U. S. P.—A mixture of caffeine and citric acid containing, when dried to constant weight at 80° C., not less than 48 per cent and not more than 52 per cent of andydrous caffeine ($C_8H_{10}O_2N_4$).

Properties: It occurs as a white powder, odorless and having a slightly bitter, acid taste. It is soluble in about 4 cc of water. On diluting this solution with an equal volume of water caffeine slowly separates but redissolves on the further addition of water.

Action and Uses: It is used as a cerebral and cardiac stimulant and as a diuretic.

Average dose: 0.3 Gm. or 5 grains.

Caffeina cum Sodii Benzoate, Caffeine with Sodium Benzoate, U. S. P.—A mixture of caffeine and sodium benzoate, containing, when dried to constant weight at 80° C., not less than 47 per cent and not more than 50 per cent of anhydrous caffeine ($C_8H_{10}O_2N_4$); and not less than 50 per cent and not more than 53 per cent of sodium benzoate ($NaC_7H_5O_2$). Preserve it in well-closed containers.

Properties: It occurs as a white powder, is odorless, and has a slightly bitter taste. It is soluble in 1.1 parts of water.

ACTION AND USES: It is used for the same purposes as citrated caffeine. It is preferred to caffeine citrate for hypodermic administration because it is more soluble in water.

Average dose: 0.2 Gm. or 3 grains (hypodermically).

Ephedrina, Ephedrine, U. S. P.—An alkaloid obtained from *Ephedra equisetina*, *Ephedra sinica* and other species of *Ephedra*. It was first obtained from a Chinese herb. It is closely related to epinephrine structurally but is more stable.

PROPERTIES: An unctuous, almost colorless solid, or white to colorless crystals or granules. It is soluble in water, in alcohol, in chloroform, in ether, and in liquid petrolatum, the latter being turbid if the ephedrine is not dry. Solutions of ephedrine are strongly alkaline to moistened red litmus paper.

ACTION AND USES: Ephedrine produces effects similar to those produced by epinephrine (adrenalin). It increases blood pressure and causes dilation of the bronchi and of the pupils of the eyes. It is used for shrinking congested nasal mucous membranes in rhinitis and sinusitis. It is also given in the treatment of asthma and hay fever. It may be given by mouth, hypodermically, or intramuscularly. The base (ephedrine) is used in ephedrine oil inhalant (usually 1 to 3 per cent in liquid petrolatum). The hydrochloride and sulfate are used in water solution. The sulfate is used in ephedrine jelly and in ephedrine syrup. The salts are not soluble in liquid petrolatum and cannot be used in the preparation of the oil inhalants.

Average dose: 0.025 Gm. or 3/8 grain.

Procainæ Hydrochloridum, Procaine Hydrochloride (Procaine), U. S. P.—Para-aminobenzoyl-diethylaminoethanol hydrochloride ($C_{13}H_{20}O_2N_2.HCl$).

PROPERTIES: It occurs as small, colorless crystals, or a white, crystalline powder, is odorless, stable in the air, and soluble in 0.6 parts of water and 30 parts of alcohol at 25° C. It is precipitated from its aqueous solutions by alkali hydroxides and carbonates but not by sodium bicarbonate. An aqueous solution (1 in 20) is neutral to litmus paper. The aqueous solution may be heated to boiling without decomposition occurring which is a decided advantage over cocaine in that procaine may be thoroughly sterilized.

ACTION AND USES: It is a local anæsthetic similar in action to cocaine but less toxic than cocaine and most other cocaine substitutes. When injected subcutaneously it exerts a prompt and powerful anæsthetic action, but the effect is not sustained. This condition is remedied by the simultaneous injection of epinephrine. It is nonirritant and has very little anæsthetic effect when applied externally to mucous membranes.

Average dose: In place of the usual average dose the following information is given: For infiltration anæsthesia, 0.25 Gm. or 4 grains in 100 or 50 cc of physiological salt solution, making a 1/4 or a 1/2 per cent solution, with 5 or 10 minims of epinephrine solution (1 in 1,000) is used; for instillations and injections, 0.1 Gm. or 1 1/2 grains in 10 or 5 cc of physiological salt solution, making a 1 or a 2 per cent solution, with or without 10 minims of epinephrine solution (1 in 1,000) is used; in ophthalmology 1 to 5 or even up to 10 per cent solutions are used; and in rhinolaryngology 5 to 20 per cent solutions with 6 to 8 minims of epinephrine solution (1 in 1,000) to each 10 cc of solution are used. Internally, owing to its feeble toxicity, 0.5 Gm. or 8 grains may be given.

Barbital and related compounds.

Barbital, or diethylbarbituric acid, was introduced under the name "veronal" and is chemically related to urea, or carbamide (the diamide of carbonic acid), and the hypnotic compounds derived from urea.

Barbitalum, Barbital (Diethylbarbituric Acid), U. S. P.

PROPERTIES: Colorless or white crystals, or a white crystalline powder, odorless, with a slightly bitter taste, and stable in the air. It is soluble in 130 parts of water, and in 14 parts of alcohol. A saturated solution in water is acid to litmus paper.

ACTION AND USES: It induces sleep and is a relatively safe hypnotic. A large number of deaths have resulted from its use, due to a single overdose or continuous administrations of small doses.

Average dose: 0.3 Gm. or 5 grains.

Phenobarbitalum, Phenobarbital (Luminal), U. S. P.—This compound is closely related chemically to barbital in that it represents barbital with an ethyl group replaced by a phenyl group.

PROPERTIES: White, glistening, small crystals or a white crystalline powder, odorless, and stable in the air. It is soluble in 1,000 parts of water, and in 8 parts of alcohol. A saturated aqueous solution is acid to litmus paper.

ACTION AND USES: It is used as a sedative and hypnotic. The action is similar to that of barbital but more powerful. It is poisonous in large doses.

Average dose: 0.03 Gm. or ½ grain.

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Section 2.—TOXICOLOGY

Toxicology is the science which treats of poisons. It is concerned with the detection, isolation, and quantitative estimation of poisons, their chemical and physiological effect on the ordinarily healthy organism, and the antidotes to their toxic effects.

A poison is a substance which may produce death, serious illness, or harmful effects when introduced into the body.

The effects of poisons may be local or remote and some poisons have both a local and a remote effect. By *local effect* is meant direct action on the part to which the poison is applied, such as corrosion and irritation, and by *remote effect* is meant the action of the poison on some organ remote from the seat of application or point of introduction. Sometimes a poison shows no effect, or only a slight one, until several doses have been taken, when suddenly an effect is produced nearly equal to that to be expected if the whole amount in the several doses had been taken at once. This is known as *cumulative effect*. The effect of a poison depends upon its solubility, the method of its introduction into the body, and the rapidity of its absorption into the system, and the method of introduction may determine its toxicity. For example, snake venom taken into the mouth and perhaps even into the stomach during first-aid treatment of a snake bite is not ordinarily harmful, but if snake venom were injected hypodermically it might be extremely poisonous.

There are various ways in which poisons may be introduced into the body, the most common being *by mouth*, *by inhalation*, and *by injection*. Poisons taken by mouth enter the circulation through absorption from the stomach and intestine and those inhaled enter the circulation through the air passages and lungs. When introduced by hypodermic injection or by injection into the urethral, rectal, or vaginal orifices poisons enter the circulation through absorption from the body tissues and if the injection is intravenous they are introduced directly into the blood stream. Poisons may also be introduced through application to open wounds and to the unbroken skin. After entering the circulation a poison is carried by the blood to the tissues, and organs susceptible to its action and attacks them.

Most of the excretion of poisons from the body takes place in the kidneys, lungs, liver, gastrointestinal tract, skin and salivary glands, and they may be excreted from the system unchanged or in the form of other compounds into which they have been transformed by the action of the various body organs and tissues. The most damaging effects of some poisons are found at the points of excretion, as in the kidneys and colon in poisoning by mercuric chloride (bichloride of mercury).

Various conditions of the individual may modify the action and effect of poisons on the body. The **age** of the person makes a great deal of difference, young children being much more susceptible to poisons than adults and younger persons more so than older ones. Personal **idiosyncrasy** has a marked influence on the action of poisons, some persons by nature being unusually *sensitive* to certain poisons while others possess a natural *tolerance* for certain poisons that is not the result of habitual use. Most persons through habitual use of certain poisons, especially the narcotics, may become so accustomed to their effects that because of the **habit** they are not poisoned when they take doses of those poisons that ordinarily would produce death. It occasionally happens, however, that instead of becoming inured to their action the continuous use of chemical poisons externally results in a condition of hypersensitiveness. The action of poisons may be considerably modified by **disease,** some diseases increasing and others lessening the action of poisons, and in the latter case large doses are usually required to produce the desired effect.

Poisoning may be either acute or chronic. *Acute poisoning* is the condition brought on by the individual taking one overdose of poison. *Chronic poisoning* is the condition brought on by the individual taking repeated doses of a poison or as the result of the absorption of the poison over a long period of time. Matchmakers, barometer and thermometer makers, painters, and wall paperers are some of the classes of people subject to chronic poisoning from phosphorus, mercury, lead, and arsenic, respectively.

Poisons may be scientifically classified as follows:

1. **Gaseous poisons:** Poisons present in the gaseous state which, if inhaled, destroy the capability of the blood as a carrier of oxygen and irritate or destroy the tissues of the air passages and the lungs, and when in contact with the skin and mucous membranes produce lacrimation, vesication, inflammation, and congestion. Examples: Carbon monoxide, carbon dioxide, hydrogen sulfide ("sewer gas"), sulfur dioxide, nitrous oxide ("laughing gas"), nitric oxide and nitrogen dioxide, ammonia gas, chlorine, bromine vapors, "war" gases, etc.

2. **Inorganic poisons:** (*a*) Corrosives. Substances which rapidly destroy or decompose the body tissues at point of contact. Examples: Hydrochloric, nitric, and sulfuric acids in concentrated form, oxalic acid, glacial acetic acid,

phenol, potassium hydroxide, sodium hydroxide, iodine, etc. (*b*) Metals and their salts. Substances which are corrosive and irritant locally but whose chief action occurs after absorption and damages internal organs, especially those of excretion. Examples: Arsenic, antimony, bismuth, copper, iron, lead, mercury, radio-active substances, tin, etc.

3. **Alkaloidal poisons:** Nitrogenous plant principles which produce their chief effect on some part of the central nervous system. Examples: Aconitine, atropine, cocaine, morphine, physostigmine (eserine), strychnine, etc.

4. **Nonalkaloidal poisons:** Various chemical compounds, some obtained from plants, having hypnotic, neurotic, irritant, and systemic effects. Examples: Barbital, salicylic acid, trinitrotoluene, acetophenetidin, digitalis, strophanthus, castor oil, croton oil, oleoresin of male fern, turpentine, santonin, cantharides, etc.

5. **Food poisons:** These may be poisonous metallic or organic substances introduced by carelessness, accident, or intention into wholesome food; poisonous substances naturally present in the vegetable or animal tissues used as food; pathogenic bacteria in the food, or poisonous substances produced in food by the changes resulting from the action of bacteria. Examples of each of the above classes are: Arsenic, lead, tin, zinc, and copper introduced from containers, soldering, chemical action, and for purposes of adulteration; the poisons found in mushrooms, sometimes in rhubarb, and roots and tubers ordinarily edible, certain species of fish and the flesh and roe of some fish during the spawning season; the causative agents of diphtheria, tuberculosis, scarlet fever, and typhoid fever in milk, of typhoid fever in or upon bread, sausage, oysters, and other foods, of botulism in or upon uncooked sausages, ripe olives, and other fruits and vegetables, and the ingestion of meat containing encysted worms or the larvæ of worms; and the poisons, commonly known as ptomaines, which result from the decay or decomposition of food substances.

For convenience of study the following **general classification of poisons** according to their chief effects on the body will be used:

Corrosives.—Substances which rapidly destroy or decompose the body tissues at point of contact. Examples: Hydrochloric, nitric, and sulfuric acids in concentrated form, oxalic acid, glacial acetic acid, phenol, potassium hydroxide, sodium hydroxide, iodine, etc.

Irritants.—Agents that do not directly destroy the body tissues but set up an inflammatory process at the site of application or contact. Examples: Potassium nitrate, zinc chloride, zinc sulfate, ferrous sulfate, silver nitrate, arsenic, iodine, phosphorus, etc.

Neurotics.—Poisons which act on the brain, spinal cord, and the general nervous system. Examples: Opium, hydrocyanic acid (prussic acid), ether, chloroform, aconite, nux vomica, belladonna, ethyl and methyl alcohol, etc.

The **general symptoms of poisoning** by poisons of any of these classes are given next, and, in addition, the symptoms of individual poisons will appear in the table describing those poisons.

Corrosives.—Immediately there is an acid, caustic, burning pain in the mouth, with severe burning pain in the œsophagus and stomach. This is followed by retching and vomiting of the stomach contents mixed with dark-colored liquid and shreds of mucous membrane from the mouth, œsophagus, and stomach; the inside of the mouth is corroded and the lips present the characteristic stain if an acid has been used. Swallowing is very difficult; respiration is impeded; the abdomen is tender and distended with gas; the temperature is high; and the countenance is expressive of anxiety and great suffering.

IRRITANTS.—Nausea, vomiting, and purging (frequently the vomited matter and stools contain blood); pain and cramps in the abdomen. In some cases there is inflammation of the urinary tract.

NEUROTICS.—As it is a difficult matter to give general symptoms of this class of poisons, they are here classified under—

(*a*) *Depressants*, which are characterized by a period of exhilaration followed by drowsiness and stupor; slow and stertorous breathing; cold, clammy skin; livid countenance, slow pulse, muscular relaxation; dilated or contracted pupils, insensibility to external impressions, and

(*b*) *Excitants*, characterized by rapid and feeble pulse; delirium; hot and dry skin; a sense of suffocation and inability to breathe; shuddering, and jerking of muscles; dilated or contracted pupils; disordered vision; sometimes convulsions and tetanus (as in the case of strychnine poisoning).

GASEOUS POISONS.—Irritation and corrosion of the respiratory tract, with resultant bronchitis (either mild or severe); irritation of the eyes, mouth, stomach, and kidneys.

FOOD POISONS.—Gastrointestinal distress, nausea, vomiting, diarrhœa, urticaria, circulatory and nervous disturbances are the general symptoms of food poisoning and they may vary from mild discomfort to violent disturbance of the normal body functions.

The **treatment of poisoning** consists of: 1. Removal of the poisonous substance from the stomach; 2. Administration of antidotes; 3. Elimination of the poison from the circulation; and 4. Neutralization of the systemic effects of the poison. Only the first two parts of the treatment will be discussed here, the other two being particularly within the province of the medical officer.

Removal of the poison from the stomach may be accomplished by the use of emetics (agents used to produce vomiting) and washing out of the stomach with a stomach tube.

There are two kinds of emetics: (*a*) *Local*, which act by irritating the ends of the gastric, œsophageal, and pharyngeal nerves; and (*b*) *Systemic*, which act on the vomiting center in the medulla through the medium of the circulation.

Commonly used emetics are powdered ipecac, 30 grains; ground mustard, 2½ drams; tartar emetic, ½ to 1 grain; zinc sulfate, 10 to 20 grains; copper sulfate, 5 to 7½ grains; fluidextract of ipecac, 15 to 30 minims; tepid water, large quantity; alum, 60 grains to 8 fluidounces of water; use of index finger; apomorphine hydrochloride (hypodermically), $\frac{1}{15}$ to ⅛ grain.

Antidotes are agents which counteract the effects of a poison, and are classified as: (*a*) *Chemical antidotes*, which combine directly with the poisons and render them inert or harmless or produce a more insoluble compound and thus delay the absorption of poisons; and (*b*) *Physiological antidotes*, which counteract the effect of poisons on the system. Substances preventing absorption of poisons by holding them in suspension or by coating the stomach are considered as a third class and are known as *mechanical antidotes*.

The primary purpose of treatment in a case of poisoning is *to prolong the life of the individual if possible.* With that objective ever in mind the duties of a person attending a case of poisoning are:

1. To quickly get the bulk of the poison out of the stomach;
2. To antidote the remainder of the poison left in the stomach;
3. To eliminate from the system that portion of the poison which has been absorbed;
4. To treat the symptoms as they arise; and
5. To take possession of all foods, medicines, vomited matter, fæces, urine, and anything that may be of value in determining whether the poison was

taken accidentally or intentionally, or whether criminally administered. The nature or identity of the poison may have to be determined from such things and in cases of food poisoning it is most important to collect them.

Cases of poisoning frequently are met with when it is almost impossible to obtain much or any information relative to the nature or type of poison taken. Any delay in treatment may result in serious consequences. Therefore every hospital corpsman should possess some practical knowledge of how to manage a poisoning case when the nature of the poison is unknown.

For the purpose of **general treatment in unknown poisons**, the case may be considered as one of two kinds; it may be either a case where the local effects of the poison have injured the mucous lining of the mouth, œsophagus, and stomach to an extent contraindicating the use of instruments or emetics for evacuating the stomach; or, it may be a case where the poison has had but little or no local effect on the mucous lining of the alimentary tract, and therefore one in which it would be safe to use a stomach tube or an emetic.

Poisons coming under the classification of "Corrosives" generally produce conditions such as mentioned in the first instance. They have a more or less injurious and even destructive effect on the lining of the mouth and stomach, and naturally in such cases the introduction of any sort of instrument, even a soft rubber stomach tube, may result in a perforation in the weakened wall; in such conditions, even rupture of the stomach may be caused by emesis. Poisons classified under "Irritants" and "Neurotics" have, generally, no special local or injurious action on the mucous membrane of the mouth and stomach, and therefore in such cases the stomach may be evacuated and washed by the aid of a stomach tube, or in the absence of a stomach tube the use of emetics could be resorted to without fear of injury.

Even when the exact nature of the poison is unknown, one seldom finds it difficult to determine whether the offensive material belongs under the classification of "Corrosives" or not; a corrosive leaves unmistakable signs about the lips and mouth. When the local condition points to a corrosive poison, the evidence usually indicates also whether it is of the acid or alkali type. In the case of an acid, the general treatment is the same as that outlined under "Hydrochloric acid," while the general treatment for almost any strong alkali is outlined under "Caustic alkali." In neither case are the stomach tube or emetics employed.

In cases where there are no signs of injury to the lining of the mouth, the probabilities are that the poison is one of the so-called "Irritants" or "Neurotics"; that is, the poison may be a salt of one of the poisonous metals, as arsenic, mercury, copper, tin, zinc, silver; or it may be one of the alkaloidal drugs of opium, belladonna, nux vomica, or perhaps one of the many alkaloids, among the more common of which may be mentioned morphine, codeine, cocaine, heroin, atropine, and strychnine, although in an unknown case it would hardly be strychnine, for the symptoms in a case of strychnine poisoning are very characteristic. The patient may be suffering from poisoning by one of the drugs known as glucosides, of which the active principles of digitalis are examples; or, the case may be one of poisoning by grain alcohol, wood alcohol, chloral, a cyanide, phosphorus, iodine (leaves stains on lips), or phenol (the undiluted form has corrosive action).

Almost the entire range of possibilities for poisons coming under either the classification of "Irritants" or "Neurotics," may be treated with a general antidote having properties of precipitating them, or of physically or chemically combining with those poisons in a manner to reduce their toxicity and, in some instances, to convert them into altogether harmless compounds. The following

is considered an excellent general antidote: Take one tablespoonful of magnesium oxide, 1 tablespoonful of tannin (tannic acid), 3 tablespoonfuls of powdered charcoal, and a small amount of water and mix together into a paste, thin the paste by further addition of water, about half filling an ordinary glass tumbler. This general antidote is administered in doses of from 1 to 2 ounces each. Wash the stomach with lukewarm water or saline solution between doses of the antidote, which should be repeated at intervals of 10 minutes so long as may appear necessary. Occasionally, after washing out the stomach and between doses of antidote, give the patient a thin paste of starch, the white of two eggs or other albuminous substance.

Always use the stomach tube when possible under the circumstances; the stomach tube facilitates the administration of antidotes as well as the washing out of the stomach at short and frequent intervals, and permits the handilng of the case in a positive manner, in so far as it places under control the administration of emergency treatment. When the stomach tube is not used, the patient is required to assist and work on himself; he must swallow large volumes of antidotal mixtures, saline solution, warm water, and besides he must take emetics to promote vomiting. All such efforts on the part of the patient have a tendency to weaken him and thereby lower his general resistance. However, when for any reason the stomach tube is not employed, antidotes must be taken by mouth and removed by emesis, which may in some cases be brought on by the tickling of the fauces but more often requires the use of emetics, the following being a very effective one and very easily prepared: About 2 teaspoonfuls of mustard in a glass of warm water. Soapy water is an excellent emetic, made by dissolving castile soap in water, this also has antidotal action on a number of metallic salts, principally mercuric chloride. Two teaspoonfuls of table salt dissolved in a glass full of warm water is sometimes used as an emetic with good effect.

After removing the residual poison from the stomach by the use of the stomach tube or emetics, magnesium sulfate should be given in small doses until a total of about 1½ ounces has been taken. No oils should be given unless it is certain that the patient is not suffering from an oil-soluble poison such as phosphorus or phenol.

This outline relative to the management of poison cases when the nature of the poison is not known covers only those steps that have to do with the removal of unabsorbed portions of poison, the residual poison, from the stomach, but the hospital corpsman should not lose sight of the fact that the treatment also calls for the application of proper measures to counteract that portion of the poison that may have been absorbed and carried in the system of circulation. No definite outline of treatment can be laid down for combating the possibilities which may arise from absorbed poisons; this part of the treatment is based entirely on the symptoms the case presents. Effort to hasten the elimination of absorbed poison would include the giving of large quantities of water, the use of hot packs to stimulate skin action, and probably the use of enemas if deemed advisable under the circumstances.

The hospital corpsman should endeavor to alleviate symptoms and distress of the patient by such means as come within his knowledge and experience in the general care of the sick, using hot water bags, ice bags, etc., as indicated. Physiological antagonists should not be administered in the absence of definite information as to the nature of the poison ingested. Medication should be limited to drugs whose physiological action is clearly understood by the hospital corpsman.

SYMPTOMS OF POISONING BY CERTAIN POISONS

Symptoms	Suspect poisoning by—
Poison suddenly fatal	Hydrocyanic acid; potassium cyanide; phenol; oxalic acid; poisonous gases.
Collapse, with cold clammy skin and rapid pulse.	Corrosive acids or alkalies; arsenic; antimony.
Convulsions	Strychnine.
Coma	Alcohol; opium (preparations); chloral hydrate; carbon monoxide or dioxide.
Active delirium	Alcohol; atropine; belladonna; hyoscyamus; cannabis indica; camphor.
Mental hebetude	Opiates (chronic); cocaine (chronic).
Double vision	Belladonna; gelsemium.
Blindness	Methyl (wood) alcohol.
Ringing in the ears	Quinine; salicylic acid, chenopodium.
Salivation (ptyalism)	Mercurials; aconite; pilocarpine.
Pupils—	
Dilated	Atropine; homatropine; gelsemium; hyoscyamus.
Contracted	Opium (preparations); phenol; pilocarpine; physostigmine
Skin—	
Moist	Opiates; aconite; pilocarpine; salicylic acid and salicylates.
Hot and dry	Atropine; cocaine; scopolamine.
Cyanotic	Carbon dioxide; coal-tar products.
Dark but not cyanotic	Mercury; lead; arsenic.
Yellow	Phosphorus; potassium chlorate or nitrate.
Eruptions	Bromides or iodides internally; croton oil, poison oak or ivy externally.
Numbness and tingling	Aconite; beginning lead palsy.
Discoloration of tongue and membranes of mouth and throat—	
White	Corrosive acids; alkalies; phenol; bichloride of mercury.
Yellow	Nitric acid (changing to brown).
Brown	Iodine; bromine; potassium permanganate.
Greenish blue	Copper salts; Paris green.
Vomiting and purging	Arsenic; antimony; mercuric salts; ptomaines.
Vomiting without purging	Apomorphine; aconite.
Obstinate constipation	Lead; opiates.
Pulse—	
Slow	Opiates; digitalis (at first); physostigmine.
Rapid	Atropine; hyoscyamus; cocaine.
Great muscular weakness	Aconite; digitalis; physostigmine; salicylic acid; carbon dioxide.
Muscular tremors	Lead; mercury; alcohol.
Urine—	
Yellow	Santonin; picric acid.
Red	Sulfonal; trional.
Dark, smoky, or greenish	Phenol; tar; creosote.
Scanty or suppressed	Oxalic acid; atropine; potassium chlorate or nitrate.
Strongly acid	Mineral acids; oxalic acid.
With odor	Turpentine; copaiba; cubeb.

TABLE OF POISONS, SYMPTOMS AND TREATMENT.

Aconite. (Neurotic.)

SYMPTOMS: Palor; salivation; tingling and numbness in mouth and fingers; burning in throat and stomach; nausea and vomiting; slow, feeble and irregular pulse; rapid and shallow respiration; muscular weakness; cold, clammy skin; difficult swallowing; impaired voice; cramps in extremities and possible tetanic convulsions; death from paralysis of the heart and of respiration.

TREATMENT: Place patient on back with head lower than feet; give animal charcoal (1 tablespoonful), tannic acid (10 to 30 grains), tea or strong coffee, as a chemical antidote. Apply heat externally; use stomach tube or siphon of rubber tubing to empty stomach *(avoid emetics)*; administer stimulants, as aromatic spirit of ammonia, caffeine, atropine, ether, strychnine, and amyl nitrite. Physiological antagonist is digitalis. Artificial respiration if breathing stops.

Alcohol, ethyl. (Neurotic.)

SYMPTOMS: Exhilaration, staggering gait, deep sleep with stertorous breathing, acute gastritis and profound depression. Delirium tremens frequently occurs after an alcoholic debauch.

TREATMENT: Emetics or the use of the lavage tube, purgatives, proper diet, external heat. Ammonia inhalations, atropine, caffeine, digitalis, strychnine, oxygen, artificial respiration.

The morbid conditions with which acute alcoholism may be confounded are: Apoplexy, opium narcosis, concussion of the brain, uræmia, epilepsy, and even acute pneumonia. The differential diagnosis is difficult to make in a state of deep coma. The pupils in alcoholism may be either dilated or contracted.

Alcohol, methyl. (Neurotic.)

SYMPTOMS: Primary, dizziness, headache, nausea and vomiting, dimness of vision, with befogging of the brain; later, widely dilated pupils with ultimate blindness, weakened circulation, stupor, coma, delirium, convulsions, cold clammy skin, subnormal temperature, death from paralysis of respiratory center.

TREATMENT: Immediate evacuation of the stomach by means of a stomach tube followed by washing the stomach with a very dilute potassium permanganate solution, then warm water; administer two or three ounces of a solution of magnesium sulfate (Epsom salt) before removing the stomach tube; administer stimulants; apply external heat. It is beneficial at times to do a venesection; remove a quantity of blood and administer physiological saline solution intraveneously. (This should be done by medical officers only). Stupor from wood alcohol poisoning is treated by introducing into the system large doses of sodium bicarbonate and sodium citrate solutions, either by mouth or by rectum.

Arsenic. (Irritant.)

Present in Fowler's solution, Paris green, rat poisons.

SYMPTOMS: Faintness and depression come on in about one-half hour; intense pain in the region of the stomach; tenderness of abdomen on slight pressure, nausea and vomiting increase by every act of swallowing; purging, bloody stools; cold, clammy skin; feeble pulse.

TREATMENT: Emetics (one of mustard, 1 part, salt, 6 parts, in large amount of water may be used); wash out stomach with warm water and milk. Then give a wineglassful of freshly prepared Magma of Ferric Hydroxide. Reliance must be placed on copious gastric lavage frequently repeated as the poison is not freely soluble. Warmth externally and demulcent drinks. Give opium, atropine, strychnine, and spirit of nitrous ether.

Physiological antagonists to combat collapse are caffeine and digitalis.

Atropine. (Neurotic.)

SYMPTOMS: Redness or rash of the skin; nose, mouth, throat and bronchi become dry; voice becomes hoarse; swallowing difficult; pulse full and bounding, later feeble and rapid; pupils dilated; vision disordered; predisposition to laugh and talk loudly. There may be wild and maniacal delirium; and mental depression; suppression of the urine; convulsions; death occurs usually from asphyxia.

TREATMENT: Wash out stomach with a solution of potassium permanganate (20 grains to 1 pint of water); precipitate alkaloid in stomach by dilute solution of iodine in water (6 drops of tincture to 4 ounces) or of tannic acid; if not available give strong tea and an emetic. Apply an ice cap to the head;

stimulate with strong coffee and eliminate the poison absorbed by the use of cathartics and diuretics. Treat symptoms as they arise.

Physiological antagonists are morphine (cautiously administered), ether to control spasms, and caffeine for its effect on the heart and brain; pilocarpine.

Belladonna. (Neurotic.)

Symptoms and treatment same as atropine.

Bichloride of Mercury. (Corrosive.)

See Mercury.

Caustic alkalies. (Corrosive.)

Potassium and sodium hydroxides; ammonia water; quicklime; lye.

SYMPTOMS: *See* general symptoms of corrosives.

TREATMENT: Diluted acids, especially citric or tartaric; lemon or orange juice; vinegar; milk; oil. No emetics or stomach tube. Place patient on back. Warmth externally. Cold air. Give strychnine, opium, caffeine, aconite, and digitalis as indicated. *Diluted hydrocyanic (prussic) acid must not be used.*

Cocaine. (Neurotic.)

SYMPTOMS: Dilated pupils; talkativeness, restlessness, excitement, delirium, hallucinations, mania, followed by depression; nausea, vomiting, numbness and tingling in hands, headache, dizziness; small, rapid pulse; irregular respiration; later, convulsions, collapse, cyanosis, clammy skin, shock, possibly death.

TREATMENT: Wash out the stomach with a solution of potassium permanganate (20 grains to 1 pint of water) or tannic acid or tea. Keep patient in recumbent position; apply external heat; fresh air; artificial respiration if necessary.

Physiological antagonists are morphine, amyl nitrite, chloral, chloroform, and ether.

Digitalis. (Neurotic.)

SYMPTOMS: Pulse slow and full, then rapid and irregular; nausea, persistent vomiting, colic, and purging; thirst; vertigo and disturbances of vision and hearing; headache; muscular weakness; respiration rapid and feeble; cyanotic skin; coma and convulsions. Death occurs from sudden paralysis of the heart.

TREATMENT: Wash out the stomach with tannic acid solution, or tea, or potassium permanganate solution (20 grains to 1 pint of water). Keep patient quiet and in a horizontal position. External heat, particularly over abdomen. Give magnesium sulfate, aromatic spirit of ammonia, alcohol, strychnine, oxygen, atropine. Artificial respiration if necessary.

Physiological antagonists are aconite for the effects of a large dose and opium for the effects of its long-continued use.

Food Poisoning. (*See* pages 377 and 379.)

SYMPTOMS: (Described on page 260.)

TREATMENT: Must be adapted to the individual conditions found. If early treatment is possible, remove harmful contents from alimentary tract by use of stomach tube or emetics, high colon flushing, and active catharsis if there is no reason to suspect the presence of appendicitis or perforation of the intestine. Saline infusion given hypodermically or intravenously should be used to aid in the elimination of the poisonous or noxious substance from the circulation. (This should be done by medical officers only.)

Heroin. (Neurotic.)

See Morphine.

Hydrocyanic (prussic) acid and cyanides. (Neurotic.)

SYMPTOMS: Sudden collapse; unconsciousness; a convulsive seizure; cyanotic face; clenched teeth; open and staring eyes; perhaps bloody froth on lips; and death in a few seconds; or, collapse; slow, labored, and gasping respiration; slow pulse; disturbed mental activity; dilated pupils; unconsciousness; vomiting; general convulsions with involuntary defæcation and urination, then coma, and death from paralysis of respiratory center. Odor of peach kernels on breath.

TREATMENT: Stomach tube if possible. Diluted ammonia; opium, to relieve pain; alternate cold and warm affusions; atropine and heart stimulants; artificial respiration; recumbent position; external heat.

Hyoscyamus. (Neurotic.)

Symptoms and treatment same as atropine and belladonna.

Iodine. (Corrosive and irritant.)

SYMPTOMS: Acrid taste in mouth; pain and sense of great warmth in throat; severe pain in œsophagus, stomach, and abdomen with violent vomiting and purging (vomited matter may contain traces of iodine); upper digestive tract and stomach corroded and stained a dark brown; intense thirst; rapid, feeble pulse; face pale; suppression of urine; convulsive movements and collapse.

TREATMENT: Free administration of starch in water or any starchy substance; induce vomiting; give demulcent drinks; digitalis, atropine, or strychnine hypodermically; external heat; careful nursing.

Irritant gases.

SYMPTOMS: Irritant gases produce irritation and corrosion of the respiratory tract, causing bronchitis, which may be more or less severe. Irritation of the eyes, mouth, stomach, and kidneys also are produced.

TREATMENT: Remove the patient from the source of the gas; give inhalations of ammonia and begin artificial respiration at once. When free respiration is established, give magnesium oxide or diluted alkalies.

Lead.

SYMPTOMS: A sense of constriction about the throat; metallic taste in mouth; cramps; stiffness of abdominal muscles; blue line around the gums; paralysis of upper extremities; dropped wrist; vomiting of white flaky matter and constipation.

TREATMENT: Free administration of soluble sulfates, particularly magnesium sulfate, followed by milk and raw eggs; give emetics and use stomach tube; opium to allay irritation. Chronic poisoning is best treated by iodides to saturation of the system, sodium iodide or calcium iodide being the best. (Painters are subject to chronic lead poisoning.)

Mercury. (Corrosive.)

The metal itself is not poisonous but may form toxic compounds if it remains in the body for any length of time. Inorganic compounds of the mercur*ic* type, as mercuric chloride (commonly called bichloride of mercury and corrosive sublimate), red mercuric iodide, yellow mercuric oxide, etc., are usually soluble and actively toxic, while those of the mercur*ous* type, as mercurous chloride (commonly called calomel), yellow mercurous iodide, etc., are very insoluble and much less toxic, but may change in the body to the mercuric type and then cause poisoning. Most cases of mercury poisoning are caused by

mercuric chloride being swallowed, injected for therapeutic use, or used in the antiseptic dressing of wounds.

SYMPTOMS: Acrid, metallic taste in mouth; thirst; burning pain in mouth, throat and abdomen; nausea and vomiting of bloody material; straining to empty bowels or bladder; purging with mucous and blood in stools; suppression of urine; shock; and collapse. Face flushed; quick irregular pulse; cold extremities. Mucous membranes of lips, mouth, tongue, and throat may appear shriveled and white.

TREATMENT: Give whites of eggs (white of 1 egg for each 4 grains of mercury taken) immediately. Follow this by an emetic (20 grains of zinc sulfate or 2 teaspoonfuls of mustard in tepid water) and wash out the stomach repeatedly to prevent absorption and reabsorption of the poison. Copious draughts of albumin water will promote vomiting but too much albumin should not be given as albuminate of mercury is resolvable and consequently repeated washing out of the stomach is necessary. While it is stated that whites of eggs are of no value as an antidote in mercury poisoning the foregoing treatment should be given at once in order to quickly remove from the stomach as much of the poison as possible.

In Remington's Practice of Pharmacy it is stated that the only antidote for mercury poisoning known to be absolutely effective is Sodium Formaldehyde Sulfoxylate, which is administered as follows: Wash out the stomach with a 5 per cent solution in distilled water, leaving about 200 cc remaining in the stomach. Immediately following this, 10 grams of the drug dissolved in 100 to 200 cc of sterile distilled water is slowly injected intravenously, taking from 20 to 30 minutes to give the injection. If the solution cannot be retained in the stomach, high colonic irrigations of the drug in 1 in 1000 solution should be given.

After administering the antidote give demulcent drinks, milk, and ice water. External heat. Give opium, atropine, caffeine, strychnine, and camphor as indicated.

Mineral and organic acids. (Corrosive.)

Hydrochloric, nitric, and sulfuric acids, acetic and oxalic acids.

SYMPTOMS: Lips, mouth, tongue, and throat burned (dark-brown or black by hydrochloric and sulfuric acids, yellowish-green to orange-yellow by nitric acid, brownish by acetic and oxalic acids); burning pain and destruction of tissues in mouth, throat, and stomach; vomiting; feeble pulse; difficult speaking and swallowing; cold clammy skin; shock; perhaps convulsions and coma in oxalic-acid poisoning; collapse. Possible yellow stains on clothing in hydrochloric acid and dark brown to red in oxalic acid poisoning.

TREATMENT: *Do not use stomach tube. Do not use emetics if acids are in concentrated form. Do not use alkalies of sodium or potassium to neutralize oxalic acid.* Give milk of magnesia, chalk, limewater, if necessary taking plaster off walls, powdering it and mixing with water, to neutralize the acid. Baking soda and soapsuds may be given to neutralize hydrochloric acid. Follow with olive oil, barley water, linseed oil, mucilage of acacia, albumin, or milk to protect membranes. Place patient in recumbent position. External heat. Give aromatic spirit of ammonia, atropine, caffeine, strychnine, and opium as indicated.

Morphine. (Neurotic.)

See Opium.

Nux vomica. (Neurotic.)

See Strychnine.

Opium. (Neurotic.)

Symptoms: Usually there is a period of mental exhiliration and physical ease with quickened pulse which is followed by dizziness, drowsiness, languor, and nausea; slow weakened pulse; slow stertorous breathing; cold clammy skin; extremities cold; muscular relaxation; cyanosis; livid countenance; pupils contracted (pin point) but may dilate just before death; insensibility to external impressions; deep sleep from which, if the patient be aroused, there will be an irresistible predisposition to go back to sleep. Death occurs by paralysis of the respiratory center.

Treatment: First remove the poison from the stomach by the use of the stomach tube or emetics. The stomach wash, if used, should contain 20 grains of potassium permanganate to the pint of water. After the stomach has been washed out with this solution, a little (about 1 fluidounce) should be left in the stomach. In the absence of potassium permanganate an emetic should be administered hypodermically (emetics by mouth are generally useless), and after evacuation of the stomach give tannic acid in some form. Cathartics and diuretics should be administered to prevent absorption. Caffeine or strong coffee is very efficient. Efforts should be made to keep the patient awake, slap the face and neck with cold, wet cloths and force walking, but no violence should be used. External heat. Oxygen and artificial respiration if necessary.

Physiological antagonists are caffeine, cocaine, ammonia, strychnine, amyl nitrite. Atropine (1/60 grain) may be used, but only one dose should be given.

Phenol (carbolic acid). (Corrosive.)

Symptoms: White burns about mouth, lips, tongue, and throat. Burning pain in the mouth, throat, and stomach; vomiting (vomitus and breath reek with characteristic odor); headache; cyanotic or pale face; contracted pupils; rapid pulse; irregular, stertorous breathing; muscular weakness; subnormal temperature; patient rapidly becomes comatose; collapse.

Treatment: Immediately wash out the stomach with warm water or strong solution of magnesium or sodium sulfate. Give demulcent drinks, milk, egg albumin, etc. Then follow with stimulants, as atropine, hypodermically, or coffee; apply hot-water bags and warm blankets. *Do not give alcohol, oils, or glycerin,* as they will cause absorption of the drug. Alcohol may be used for local burns.

Stramonium. (Neurotic.)

Symptoms and treatment same as atropine.

Strychnine. (Neurotic.)

Symptoms: A sense of suffocation and inability to breathe; shuddering and jerking of the muscles; sense of stiffness about the neck; twitching and jerking of lower limbs and quivering of entire body; convulsions—the body becoming rigid and bent forward, *emprosthotonos;* backward, resting on the heels and head only, *opisthotonos;* or to one side, *pleurosthotonos;* the features assume a peculiar, stiff grin called *risus sardonicus.* During convulsions there is cyanosis, weak, rapid pulse, and dilated pupils, while between convulsions there is general relaxation, perspiration, weariness, and drowsiness. Convulsions are induced by noise, drafts of air, jarring, or sudden bright light. Patient remains conscious until the end and is fully aware of what goes on about him.

TREATMENT: Administer emetics until free vomiting is induced. Evacuate stomach by washing it out with a solution of potassium permanganate (20 grains to 1 pint of water) or a diluted solution of iodine, tannic acid, and finely powdered charcoal. Chloroform inhalations to relieve pain and quiet spasms. Chloral hydrate and potassium bromide in large doses are useful. Patient must be kept in a recumbent position during treatment and must be kept in a dark room remote from all noises. Artificial respiration if necessary.

Trinitrotoluene (T. N. T.) poisoning.

Because of the extensive use of this substance on board ships and in naval magazines ashore, poisoning caused by it is not uncommon.

SYMPTOMS: The skin of the hands, arms, and exposed parts become seriously irritated and inflamed. When the fumes are inhaled the respiratory tract is irritated and there is sneezing, coryza, nose bleed, watering of eyes, dry cough, sore throat, and pain in chest; if swallowed there is spasmodic gastric pain, nausea, vomiting, griping diarrhœa or constipation, frequent urination, headache, dizziness, general weakness, drowsiness, pallor or cyanosis. Changes in blood corpuscles occur and there is loss of hæmoglobin resulting in anæmia. Bile pigments are present in the urine and the skin and hair frequently turn yellow. Chronic poisoning results in a temporary enlargement of the liver, with subsequent atrophy, and in degeneration of the kidneys. Prophylactic measures consist of applying a solution of shellac, castor oil, and alcohol to the exposed parts of the skin, or, better, cover the arms with stockings and the hands with gloves impregnated with this solution. The entire face should be covered with a special mask, containing glass or other transparent noninflammable material, so that there may be no interference with vision.

TREATMENT: The poison may be removed from the skin with a solution of sodium hyposulfite. Remove the patient from the vicinity of the substance, provide absolute rest, fresh air, and simple diet. Large amounts of water with large doses of sodium citrate and sodium bicarbonate should be given. Restrict the meat intake, give small doses of iron daily, and regulate the bowels.

Gasoline, benzine, and naphtha poisoning.

Gasoline poisoning frequently results from exposure to the fumes in motor launches and in places which are confined and shut off from free access to the outside air. Men attempting to siphon gasoline from a container by means of a hose frequently swallow an amount which is harmful. Inhalation of the vapors of these substances when used as paint solvents, in rubber manufacture, in dry cleaning, in work on automobiles, in cleaning tanks and tank cars, etc., may cause poisoning.

SYMPTOMS: When the fumes or vapors are inhaled there is first dizziness, nausea, vomiting, constriction of the throat, headache, staggering and trembling of the hands and arms (the so-called "naphtha jag") and later, partial or complete insensibility, slow respiration, weak and scarcely perceptible pulse, convulsions, and death. There is a tendency to mania during return to consciousness in cases recovering from the poisoning. If swallowed there is shortness of breath, cyanosis, cold, clammy skin, coma, and death. External applications of these substances may produce inflammation of the skin or pustular eruptions.

TREATMENT: Remove the patient to the open air, remove all gasoline, benzine, or naphtha-soaked clothing, apply external heat if necessary. Administer stimulants (by enema if necessary) and treat symptomatically. (*See* under Treatment for Carbon Monoxide Poisoning in note following.)

Symptoms from the ingestion of gasoline resemble those caused by acute alcoholism, the patient is very apt to develop mania and later become unconscious. This condition should be treated by emptying the stomach by means of a stomach tube, followed by washing the stomach with very dilute potassium permanganate solution, then with warm water. It is advisable to administer two ounces of a solution of magnesium sulfate before withdrawing the stomach tube. Treat symptomatically by applying external heat, stimulants when indicated, etc.

NOTE.—Carbon monoxide is contained in the fumes of gasoline, benzine, and naphtha and when inhaled results in the formation of carbon monoxide hæmoglobin. The treatment indicated is: 1. Remove the patient from atmosphere containing monoxide; 2. Administer oxygen as quickly as possible and in as pure a form as is obtainable, preferably from a cylinder of oxygen through an inhaler mask; 3. If breathing is feeble, start artificial respiration at once by prone-pressure method; 4. Keep the patient flat, quiet, and warm; 5. Afterwards give plenty of rest.

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CHAPTER V

Section 1.—NURSING

In a broad sense the word nursing means caring for the sick or injured. More specifically it means the skillful use of scientific methods in applying therapeutic measures to the sick or injured, thereby materially assisting in their recovery and promoting their physical and mental well-being.

The individuals who carry out such measures may be of either sex and are spoken of as nurses. To qualify for nursing in civilian life nurses receive training and instruction in the scientific principles of nursing in training schools for nurses which usually are connected with hospitals. In the Navy most actual nursing is done by hospital corpsmen who usually receive their training and instruction in the Hospital Corps Schools and in naval hospitals under the supervision, largely, of members of the U. S. Navy Nurse Corps.

The qualifications necessary for those upon whom falls the nursing care of the sick or injured may be classified under three headings, *physical, mental,* and *moral.* In the discussion of these qualifications which immediately follows, their application to naval hospital corpsmen, for whose instruction and guidance this section has been principally prepared, will be considered.

Physical qualifications require health, strength, and endurance, and these can be maintained only by the faithful practice of habits of personal cleanliness, strict obedience to the laws of hygiene, avoidance of causes of indigestion, the securing of a sufficient amount of fresh air, sleep, exercise, and recreation, and prompt attention to all minor ailments. Good health habits include daily bathing, frequent brushing of the teeth, keeping the hair properly cut and clean, regular habits of eating and sleeping, and plenty of exercise in the open air. It is most important in nursing that the hands be kept clean and the following rules should be observed: 1. Always wash the hands before eating and after cleaning; 2. Always wash the hands before and after caring for a patient; 3. Keep the finger nails short, well-filed, and clean; 4. Keep the hands away from the face and do not pick at the face; 5. Do not allow abrasions on the hands to go unattended; 6. Keep the skin on the hands smooth, using a lotion if necessary. An infected wound on the body or any other infection should be reported at once in order that both the patient and the nurse may be protected.

To be mentally qualified requires education, judgment, the faculty of observation, a sense of order, and a good memory. Higher education, although desirable, is not absolutely essential for the success of a hospital corpsman, but he must have a high order of intelligence and a real desire to learn. With these assets it soon will be realized how important it is to know the underlying principles that govern the work in which he is engaged. Observation is the faculty of taking notice of things and requires constant practice for its development. A

hospital corpsman must be quick to observe minute details and equally quick to act intelligently in accordance with his observations. Loss of valuable time and many reproofs may be avoided by quick observation. A hospital corpsman possessing this quality, when assisting at a treatment or an operation, will notice what is required and often anticipate the doctor's needs.

Judgment is the faculty of being able to reach a correct decision; that is, knowing what is best to do or say under known conditions. A hospital corpsman's observation and judgment should be such that when two conditions are placed before him he can weigh them quickly in his mind and decide as to the relative value of each.

The sense of order must be cultivated both in mind and habits, and literally means, "a place for everything and everything in its place." A hospital corpsman should not tolerate disorder in the things about him nor should he allow confusion in his work. He must strive to make his work better than another's work. Particular care in folding gauze for dressings, folding linen, and arranging supplies helps to cultivate the habit of exactness.

Memory is very important in nursing. It requires constant practice of concentrating one's attention on the thing at hand, and of forming mental associations which will assist in recalling the things to be remembered.

Moral qualifications required by hospital corpsmen include truthfulness, obedience, dignity, tact, courtesy, sympathy, and economy.

Truthfulness in the care of the sick takes on a broad meaning and embraces honesty of purpose, frank acknowledgment of an error, prompt confession of anything left undone, absolute accuracy of statements, and the conscientious performance of minute details.

Obedience does not mean merely obeying rules and regulations, but includes prompt, unquestioning, and intelligent obedience to authority, regardless of whether the person in authority is an officer or other superior, or a fellow hospital corpsman.

Dignity, if genuine, admits of no rudeness or familiarity from others, and at the same time is free of any display of personal importance or superiority.

Tact is the ability to deal with others without giving offense; in other words, it is doing or saying the right thing at the right time.

Courtesy is defined as a well-bred consideration for others founded upon kindness, and is a very necessary qualification when the sick are irritable, fault-finding, or unjust in criticism. It must be remembered always that a sick person is like a child and often is not responsible for his speech and actions.

Sympathy is the feeling corresponding to that which the other person feels, and may be expressed by a smile or an encouraging word, but must not interfere with the carrying out of orders, treatments, or dressings. Patients are benefited by receiving proper care and treatment, although the reason for such may not be evident at the time to either the hospital corpsman or to the patient.

Economy in all things is very essential. Extravagant habits are easily acquired where there are large quantities of supplies, and must be especially guarded against.

Professional ethics may be defined as the moral obligation which a hospital corpsman owes to the service, its officers, the hospital, the ship, the station, or the training school, and to his fellow hospital corpsmen. He always should so conduct himself that he will do his part to be a credit to and add to the good reputation of the service, of the medical department, and of the unit to which he is attached.

In nursing there exists a personal relationship between the patient and the nurse and between the doctor and the nurse that must be considered. The

satisfactory maintenance of such relationships depends largely upon the nurse and in doing so much of the foregoing must be remembered and practiced.

A patient depends upon the nurse to give all possible aid in his illness, through nursing care to conserve and restore his strength and thereby assist his return to physical and mental health, to carry out the therapeutic measures ordered, and to help him to prevent incurring other illness. He also looks to the nurse to supply comfort through various nursing procedures and expects manual skill in carrying them out. It must never be forgotten that a patient is not well and the attitude of the nurse toward the patient should be such as will tend to encourage and benefit him. The nurse should show a sincere interest in the patient as an individual, should always be cheerful and willing in attending to his wants and needs, and should be tolerantly understanding of his whims and fancies. As a patient improves the nurse must endeavor to obtain his cooperation in personally doing many of the things that formerly were done for him and in gradually assuming more responsibility in recovering his health.

A doctor depends upon the nurse for the faithful carrying out of his orders for treatment, and for observing, interpreting, reporting, and recording the symptoms and signs that indicate changes in the patient's condition. And the doctor expects the nurse to do everything possible for the patient's comfort and to assist in every way in bringing about his recovery.

GENERAL NURSING CARE AND PROCEDURES

General principles underlying nursing methods.

To be effective and of value, nursing methods must be sound, and to be sound must be based on scientific principles. From many of the sciences have been obtained facts which form the scientific basis of nursing methods. A few examples will show how the sciences affect nursing. Physics contributed the clinical thermometer used to determine body temperature and, having proved that water is a good conductor of heat, caused the water temperatures in warm baths to be kept constant in order to prevent chilling the patient's body through loss of body heat to the water. From physiology it has been learned that all cell activity is work and consumes energy; consequently diets are varied according to the amount of work desired to be done in the process of digestion, and movement is reduced to a minimum in certain heart conditions and very sick patients to avoid tiring the weakened body tissues. Chemistry has shown that chemical action increases with heat; therefore warm gargles, douches, etc., are more effective than cold, and specimens for gastric analysis must be kept cool to prevent acceleration of the action of enzymes or bacteria. Bacteriology has revealed that some bacteria are not killed by disinfecting solutions that promptly kill others, that the temperature of boiling is not high enough to kill some bacteria, and that some bacteria will live in the soil without air for 10 or more years.

The application of scientific knowledge to the principles of nursing results in the better care of the patient, in providing for his greater safety and comfort, in quickly recognizing symptoms and signs, and in the use of proper remedial measures and treatment.

Observation of the patient's symptoms.

Symptoms are signs, evidences, or indications of conditions existing, imminent, or likely to follow, and noting them is an important part of the work of a trained nurse. Too much stress cannot be laid upon the development of keen observation on the part of the hospital corpsman who is doing actual nursing. Factors essential to its development and growth to a valuable and important

degree are: Alertness, intelligence, thoughtfulness, good eyesight and hearing, acute sense of smell, sensitiveness of touch, sympathetic understanding (responsiveness), sense of responsibility to patient, quick perception, sense of order, eagerness to help, practical ability to recognize when knowledge gained in classroom or elsewhere is applicable in the daily routine, knowledge of normal conditions and the effects of disease and injury, and the power and desire to learn everything possible from contact with associates and from daily experience. Constant practice of watching, listening, and reasoning, that nothing may escape notice nor its significance be lost, is an asset of great value to the patient, the doctor, and the attendant.

Symptoms are known as *objective*, those noted by an observer, and as *subjective*, those complained of by the patient, such as dizziness, faintness, weakness, and exhaustion; nausea (sensation of); pain, peculiar, indefinite, hard to describe or locate; itching, with no evidence of irritation; hunger and thirst, normal or abnormal; any peculiar feelings or sensations; fear, apprehension, chilliness, hot or cold flashes; exaggerated sensitiveness to noise, light, heat or cold; shortness of breath, and thirst for air with excessive thirst for water.

Objective symptoms are readily observed by those trained to note them and consist largely of the *general appearance* of the patient as seen by the observer. In considering the general appearance of the patient the observer notes the gait in walking; the movements of the hands, as even or restless and jerky; the position of the body, as lying at ease, restless or tense; the attitude toward others; and the type of conversation. The facial expression may be serene; placid or drawn, pale, pinched, anxious, worried, or apprehensive (evidence of pain, discomfort, or fear, or of some emotion or mental strain). The color may be pale, flushed, or bluish. The eyes may be bright or dull, normal in appearance, staring or bulging, bloodshot, the lids red or pale, the pupils of normal dilation, contracted to pin points, or extremely dilated.

In observing a patient for symptoms there are many things to which the nurse should pay special attention. The **appearance of the body** should be noted, whether it is thin or well-nourished, normal or distended and swollen. The skin may be dry or moist, warm, cool or cold, firm, flabby, dry or damp and clammy, hot or feverish, without blemish or bruised and discolored. Swellings may be hard and tense, or soft and fluctuating. Distension of the abdomen may be from gas, abnormal collection of fluid, or from the accumulation of urine in the bladder or fæces in the intestine. Joints may be normal in appearance or deformed. The temperature of the body may be normal, slightly above or below normal, or extremely high or low. Respirations may be regular, even and normal in type and frequency, or irregular, labored and painful, abnormally fast or slow, full and deep or shallow. The pulse may be normal in frequency, force and rhythm, or abnormally fast or slow; firm, strong, and elastic, regular as to force and frequency, or soft, running, rapid, intermittent, difficult to find or to count. Observation of the general appearance should include insect bites, evidence or presence of vermin or body lice and nits, and eruptions and their type. The appearance of excreta (fæces, urine), vomitus, discharges, etc., should be observed. Pain is classified as to type: Dull or sharp; stationary or radiating; steady or intermittent; colicky; excruciating or merely irritating; superficial or deep; burning or stinging; relieved or aggravated by pressure; occurring before, during, or after eating; duration, severity, location, and extent of area involved; and whether nauseating or not. Digestive symptoms include the appetite—normal desire for food, above or below normal, capricious or stable, craving for any special foods or

drink. Symptoms after eating include comfort or distress from gas, free expulsion of gas by rectum or by belching from mouth, pain or nausea.

Symptoms of abnormal conditions associated with the **eyes, ears, nose, mouth, and throat** may be visible to the observer or may be complained of by the patient and not visible to the observer. Any pain or tenderness in or, especially, behind the ear may indicate a serious condition (mastoiditis) which requires prompt attention. Discharges from the eyes must be reported immediately as they may be of a virulent character and endanger the sight. Deposits or patches on the inside of the throat should be promptly reported and smears or cultures taken. The general condition of the mouth and teeth should be carefully noted, and any sores, ulcers, redness, or swellings reported. Any coating of the tongue should be described and peculiar spots noted, either on the tongue or on the sides of the cheeks. Report the presence of any discharges from the throat or nares (nose).

A patient's **mental condition** may be described as calm, placid or nervous, excitable, irritable or hysterical, quiet or talkative, sane or delirious. He may be cheerful or depressed and melancholy; irrational, mildly or extremely so; unconscious either from delirium, shock, stupor, or coma.

A patient may **assume a position** in which the body is relaxed or rigid; the legs and arms relaxed or flexed loosely; stretched or drawn up taut and rigid; the legs may be flexed on the abdomen, or the head may be drawn back and the body bowed. The patient may be more comfortable on one side than on the other, or may be more comfortable in a sitting position. He may experience ease or difficulty in turning; his head may be drawn to one side; there may be loss of motion in a limb, or twitching and jerking of limbs or muscles.

Sleep may be described as quiet or restless, sound or light, normal or stupor-like, aroused from easily or with difficulty, and as to amount and time of sleep.

Coughs are classified as dry or loose; persistent, slight, strangling as from tickling in throat; hard, deep, hacking; chronic or of occasional occurrence; racking and with pain, followed by exhaustion; of a type with or without expectoration. The expectoration may be thick and purulent, or thin, very fluid, or frothy; colored light or dark; streaked with blood (bright red or rusty brown, possibly tuberculous or pneumonic); may be easily raised and expectorated, or raised and expectorated with difficulty.

Vomiting is described as of the following types: Projectile or without force; difficult, after gagging and intense nausea, or as involuntary and with ease. The amount of vomitus is described as of large, small, or medium quantity (approximate amount stated in cc). The character of the vomitus is described as consisting of undigested, partly, or fully digested food; as containing little or no food; as clear and watery, or colored with bile; as streaked with blood, either bright red or dark in color; as containing mucus, pus, or fæces; and as with or without pain. The odor of vomitus is classified as of normal acid odor, excessively acid, bitter odor, or as having the odor of urine or of fæces (denoting serious kidney condition or bowel obstruction.) The frequency of vomiting is described as periodic, as occurring at longer or shorter intervals, and as continuing for longer or shorter periods. The time of occurrence is described as before or after eating, or between meals, and as occurring during the night or in the day time.

The **voice** is described as being clear or hoarse; firm and full, or thin and weak; and as loss of voice. Speech is classified as intelligible or thick and mumbling, as from shock or alcoholism, and as speech which halts with spaces between, as from weakness or loss of memory.

Perspiration is described as to amount, copious or scanty; as to odor, normal or rancid, having the odor of urine or of some drug or food; as to duration of period of perspiring; time of perspiring, continuous or periodic, occurring during the night or the day; and whether coming on suddenly or gradually. Perspiration may be induced by sudden shock or nervous reaction, by an acute septic condition, or by some chronic or long standing condition causing weakness and debility; it may be the result of tuberculosis (as an example, night sweats, a common symptom). Perspiration may be accompanied by a sudden drop or a gradual fall in temperature; or followed by a gradual or sudden rise in temperature.

In describing **hiccoughs** the time of occurrence should be noted; the severity of the attack; whether it is checked easily or with difficulty; and the duration of the attack.

Eruptions of the skin should be described as to the location of the first appearance, the time of the first appearance, the progress and extent of its spread, extent of area covered; as to the character of eruption and the symptoms associated with its appearance and spread, such as rise and fall in temperature and general condition of the patient.

Numerous symptoms are associated with **heart action and heart conditions.** Palpitation is the rapid, tumultuous beating of the heart which is felt by the patient, sometimes seen by the observer in the heart region of the chest, at the temporal arteries, and in the carotid arteries visible in the sides of the neck. It may be caused by organic disease of the heart; is often the result of shock, nervousness, or fright; and it may be caused by overexertion. It is sometimes the result of hysteria, and may be the result of indigestion and pressure from gas in the stomach or intestine. A sudden, sharp, excruciating pain in the heart region is a cardinal symptom of angina pectoris. This is a serious condition and should be reported at once to the medical officer. In cases of this nature the attendant should remain with the patient and send someone as messenger for the doctor; while awaiting the arrival of the doctor, a hot-water bottle should be applied at once to the area of pain. An amyl nitrite pearl should be available so that if ordered it may be broken in gauze or a handkerchief, which should then be held under the patient's nose. Difficult breathing, with distress of different types in the heart region, may be due to irritation of the muscles or membranes of the chest walls and area surrounding the heart, to organic disease of the heart itself, to acute indigestion, or some condition causing gas in the stomach or intestine with resulting pressure upon the diaphragm.

The odor of the **breath** may be of diagnostic value. Certain odors are often characteristic of certain diseases or conditions. When the breath has any strong noticeable odor, as sweet, urinous, metallic, especially foul or fetid, a record of it should be made, and the medical officer promptly informed. Such a report may aid in establishing a diagnosis and prescribing treatment.

Urine is one of the most important secretions of the body and when examined after excretion may present many important symptoms of pathological conditions. (*See* chapter on Anatomy and Physiology for description of urine). The presence of blood, pus, mucus, and sediment of various types should always be noted. Failure of the kidneys to secrete urine is termed **suppression of urine** and is a distinctly organic condition. It is sometimes caused by injury to the kidneys or adjacent parts, is a symptom of a very grave condition, and requires prompt attention. **Retention of urine** is the failure of the bladder to eliminate the urine stored there and is evidenced by the following symptoms: A feeling of fullness in the bladder, visible distention over the bladder, pain in the

region of the bladder, headache, a keen desire to void with inability to do so, and sometimes dribbling of urine. The causes of retention of urine are restriction of the bladder muscles from nervousness, a kink in the neck of the bladder from tipping when overfull, mechanical obstruction of some kind, temporary loss of power of the sphincter muscles, temporary paralysis following injury, or from other cause, and sometimes because the quantity of urine in the bladder is insufficient to stimulate it to void.

To overcome retention and induce urination give the patient a warm urinal or a urinal containing a small quantity of warm water; run water nearby where the patient can hear it; when permissible, give copious drinks of water; if permitted, place a hot-water bottle over the bladder; if patient is able, raise him somewhat on pillows and leave him alone with the urinal (consciousness of being observed, watched, or waited for, often causes a nervous reaction which in itself makes it difficult for a patient to void). Sometimes turning the patient well over on his side, or, when permitted by the medical officer, setting him up on the side of the bed with his legs hanging over will enable him to void. (The last-mentioned methods never must be used without permission of a medical officer. Should all these methods fail to induce urination, report to the medical officer who will, if necessary, order the patient to be catheterized. Never catheterize a patient without an order from the medical officer.

Any unusual specimen of urine should be saved for observation of the medical officer who should be shown it as soon as possible after voiding, as decomposition is very rapid. The attendant should be so well informed concerning his patient that he will never fail to discover promptly any suppression or retention of urine.

Many facts concerning a patient's condition can be learned from observation of the fæces. The number of defæcations in the 24 hours should be noted. Failure of the bowel to eliminate causes absorption of poisonous waste matter and in time results in sluggish peristalsis of the intestine. A patient is often uncomfortable from a feeling of fullness in the bowel or from an accumulation of gas in the intestinal tract.

Many times headache, and sometimes nausea, is caused by inactivity of the bowel. Alteration of the size or shape of fæcal matter may indicate stricture of the bowel or an obstruction of the intestine. Hard stools indicate that the fæces have been impacted for some time and that the moisture from the intestinal content together with toxic matter has been absorbed by the system. Hard stools may also indicate that too small amounts of liquids have been taken by the patient or that some food or drug, which has a tendency to retard peristalsis or dry up secretions, has been taken. Liquid stools indicate the presence of an irritation causing increased peristalsis and increased secretions of intestinal fluid. Constipation frequently follows. The color of stools varies according to food and medicine taken and to the amount of bile poured into the intestine from the gall bladder; normally it is brown or greenish brown. Gray or gray-colored stools are an important symptom indicating a lessening of the secretion of the liver or of some obstruction to its discharge. (Morphine addicts often have pale gray stools.) If the stools are dark and tarry it is an indication that blood has remained in the intestine sufficiently long to be partly digested; it may be from a hæmorrhage high up in the intestine or in the stomach which has become well mixed through the stool. Bright red blood in the stool indicates recent hæmorrhage from the lower bowel where there is no digestion. Bright red blood on the surface of the stool indicates bleeding near the rectum, such as occurs from a rectal fistula, hæmorrhoids, or possibly from a crack or fissure of the external

anus. The presence of pus in the stool is a grave symptom, denoting usually either inflammation of the intestine, liver, or pancreas, with suppuration, or the rupture of an abscess into the intestinal tract. The presence of mucus in a stool is the result of inflammation or irritation of the mucous membrane, causing an increase in the secretion of mucus. The following parasites are sometimes found in stools: Thread worm, round worm, and amœba (found by means of the microscope); tapeworm, hookworm (enters through sole of foot). When these intestinal parasites are found precautions as for infectious cases should be taken to prevent their transmission to other patients or to other persons in the ward, and also reinfection of the original patient. All articles used by the patient should be kept for his sole use and disinfected as necessary.

Variations from normal in the *temperature, pulse,* and *respiration* indicate much concerning the condition of a patient. **Temperature** is the degree of intensity of heat of the body and as measured by the clinical thermometer represents the balance maintained between the heat produced by the activities and functions of the body and the various chemical changes within the body structure, and the heat dissipated or lost. Heat is produced by friction of the muscles, chemical action in various organs, also by hot drinks and application of heat to the exterior of the body in various ways. All points of natural friction in the body are provided by Nature with a lubricating fluid, and any interference with or shortage of this lubricating fluid causes abnormal body heat during friction, and a consequent rise in body temperature. Cool or cold drinks, applications of cold to surface of body, exposure to cold, and insufficient clothing are all means of lowering body temperature.

Body temperature is measured by means of the clinical thermometer, a small glass cylinder, the center of which is a slender hollow tube dilated at its lower end into an oblong or round bulb, filled with quicksilver or mercury which expands on the application of heat. When heat is applied to this bulb the mercury, expanding, is forced as a slender silver thread to a height depending upon the heat applied at its base. This thread-like line is magnified by the outer glass, so that when the thermometer is held at the proper angle before the eyes it may be read easily. In the United States the clinical thermometer is usually marked in degrees and tenths of degrees Fahrenheit. Normal temperature, that is, the average body temperature, of a healthy person is 98.6° F., subject to slight daily variations. This temperature varies somewhat according to where taken, rectal temperature being slightly higher and axillary temperature slightly lower than mouth temperature.

Temperature trays vary somewhat in equipment but all carry out the principle of properly cleansing and disinfecting thermometers both before and after use. Whatever receptacles are used, the thermometers should be immersed in disinfecting solution between periods of use; should be wiped free from solution before use, and wiped clean after use before return to the solution. There should be a sufficient number of thermometers on the tray to allow for disinfection of a used thermometer while going from one patient to another, if possible using one thermometer no oftener than every fourth patient. The routine equipment always required on a temperature tray consists of small paper wipes, or absorbent cotton in sufficient quantity so that none need be used a second time; waste receptacle; time-piece with second hand; temperature book and pencil; rectal thermometer in special receptacle marked "For rectal use only," and a jar of vaseline; two receptacles for holding thermometers, one marked "Clean," to hold thermometers before use, the second marked "Used," for immersion after use.

Temperature may be taken in various ways, the most frequently used methods being by mouth, by axilla, and by rectum. When taking temperature by mouth, remove the thermometer from the solution, wipe thoroughly free of solution, then grasping firmly but not stiffly between the thumb and the first and second fingers of the right hand and holding the wrist relaxed, not rigid, shake the thermometer with quick jerks, repeating as often as necessary until the mercury is down to 95° F. Then place the thermometer in a slanting position in the patient's mouth, the bulb part under the tongue and the other end outside the patient's mouth. The patient is then told to close his lips closely together on the thermometer, taking care not to bite or break the glass. Allow it to remain in patient's mouth for from two to five minutes, then remove, read carefully, and record the temperature, together with the pulse and the respiration, in a record book. Cleanse the thermometer thoroughly on removal from patient's mouth and place it in the receptacle for used thermometers. Take the pulse and respiration while waiting for the thermometer to register.

In taking temperature by axilla first wipe the axilla with a dry towel to remove all moisture; wipe the thermometer and shake down the mercury to 95° F., then insert the bulb well in the hollow of the axilla, close up to the junction of the adjacent surfaces. Hold the patient's arm close to the body, flexing his elbow, and bringing the forearm and hand up on the chest. Keep the thermometer in place for from five to seven minutes. The thermometer is then cared for in the routine manner. Temperature by axilla is approximately 1° lower than by mouth.

When taking a temperature by rectum a thermometer larger in circumference and of thicker, heavier glass is used. This lessens the danger to the rectum by breaking and otherwise. First, free the rectum from fæces; lubricate the bulb well with vaseline; and then, with gentle pressure, insert the thermometer upward and backward in the rectum until well past the sphincter muscle. Temperature should register in from three to five minutes. On removal cleanse and disinfect the thermometer before replacing it in the receptacle marked "For rectal use only." Rectal temperature is approximately one degree higher than that recorded by mouth.

In taking temperatures certain precautions must always be remembered. Thermometers used for patients suffering with communicable diseases or with septic or infectious conditions of the mouth or throat should be properly labelled for their individual use and never used on other patients. Never take the temperature by mouth immediately following hot or cold drinks or after the patient has just been smoking. Never immerse a thermometer in hot water. When taking a temperature by rectum, never allow a patient to insert the thermometer himself. If a patient's temperature suddenly goes very high or very low, without apparent cause, take it again with another thermometer to make sure there is no mistake. Closely observe the patient while taking his temperature to prevent accidents and deliberate errors. Never take by mouth the temperature of a patient who is coughing continuously, one unable to breathe through his nose, or one who for any reason cannot close his mouth. Never take the temperature by mouth of a delirious or unconscious patient.

When the temperature of the body rises above normal the condition then existing is known as fever, and it is usually accompanied by quickened pulse and respiration, increased tissue waste, and disordered secretions. The onset of fevers may be abrupt or gradual, those of sudden onset being frequently characterized by chills, acute pain, headache, and sometimes accompanied by vomiting, while those of gradual onset are characterized by headaches, un-

easiness, weariness, loss of appetite, general malaise, etc., as well as by chilly sensations. Pneumonia is an example of a fever of sudden onset, and typhoid fever of one of gradual onset.

Fevers are classified as *continuous*, *remittent*, and *intermittent*. A **continuous fever** is one in which the temperature remains continuously elevated, with only slight variations during the 24 hours. Never at any time does the temperature fall to normal or approach it. Pneumonia belongs to this type. In a **remittent fever** there is a moderate range between the highest and the lowest points, but the temperature until convalescence is always above normal. The highest point is reached in the evening, the lowest in the morning. Typhoid fever belongs to this type. In **intermittent fevers** there is a great range between the highest and the lowest points in 24 hours, the temperature rising suddenly to 104° or 105° F., and as suddenly falling, sometimes to normal or below. Malaria is a typical example of this type.

The termination of fevers occurs in either of two ways: By *crisis*, when the fever drops suddenly to normal or below, never again rising to any considerable degree, unless a relapse or some complication sets in, or by *lysis* when the fever gradually declines until it reaches normal. Most fevers terminate in this manner. During the crisis of a fever the patient perspires freely, the quantity of urine voided is sometimes increased, the pulse rate and respiration become normal, or nearly so, and following the crisis there is a marked improvement in the patient's general condition, unless the drop is so sudden and extreme as to cause shock or collapse, in which case stimulants and application of external and internal heat are indicated. Examples of diseases which usually terminate by crisis are pneumonia, influenza, measles, and typhus fever. A sudden drop of temperature in a fever does not always indicate "termination by crisis", and when accompanied by a marked increase in pulse rate, rapid respiration, excessive restlessness and feeling of apprehension, and sometimes by shock, it is a grave symptom, and frequently indicates hæmorrhage or intestinal perforation.

The **pulse** is the intermittent change in shape of arteries due to the expansion of their walls following the contractions of the left ventricle of the heart. This expansion of the walls of arteries is synchronous with the heart beat and is wavelike in character.

By the pulse *rate* is meant the number of beats to the minute counted at any point of an artery's course where they may be seen or felt. It is sometimes spoken of as the *frequency* of the pulse.

The pulse may be taken or counted at any point where an artery approaches the surface or passes over a bony prominence, firm muscle, or tissue. The locations most frequently used are the radial artery at the wrist on the thumb side; the temporal artery in front of the ears slightly above and at the outer angle of the eye; the carotid arteries in the sides of the neck (these may often be seen as well as plainly felt); the facial arteries where they pass over the lower jawbone just forward of the angle of the jaw; and the dorsalis pedis artery on the dorsal surface of the foot.

The *normal pulse* of healthy individuals may vary somewhat in rate, force, and strength, but should maintain a certain regularity and be reasonably firm and elastic if the heart is in proper condition. The normal pulse rate for a man is 65 to 80, of a woman 70 to 80 beats per minute. Conditions which influence the heart action and the pulse rate are age, sex, exercise, position, temperature, temperament, disease, injury, emotion, and excitement.

The *tension of the pulse* is dependent upon the blood pressure, and this in turn is dependent upon the strength of the heart beat, the elasticity of the

artery wall, the degree of resistance offered to the flow of blood through the arteries, the amount of blood in the vessels, and in some degree upon the viscosity of the blood. When the tension of the pulse is *high*, the artery remains distended between beats and is compressed with difficulty; sometimes it cannot be compressed even following distention and may feel like a hard cord beneath the finger. When the tension of the pulse is *low* the artery does not remain distended for even the normal time of expansion, but quickly falls, is easily compressed, and the artery feels empty. Drugs and disease as well as other conditions, such as hæmorrhage and changes in the elasticity of the arteries, may alter the tension of the pulse. To determine the tension of the pulse, the pressure required to obliterate the pulse beat is noted. Accurate measurements can be obtained only by use of the *sphygmomanometer* (blood-pressure apparatus), but an approximate idea of the tension may be obtained by increasing the pressure of the finger nearest the heart until the other finger fails to feel the pulse beat. The sphygmomanometer is an instrument made especially for the purpose of accurately estimating the blood pressure. In determining blood pressure the arm is encircled with a rubber bag which can be inflated with air and air is forced into this bag by means of a bulb which is connected with a dial or a graduated tube of mercury that registers the air pressure in the bag. When this pressure occludes the artery the pulse cannot be detected with a stethoscope distal to the bag. The pressure in the bag is then reduced gradually by opening an air cock connected with the bulb and as soon as the air pressure is sufficiently reduced to let the pulse be heard, the reading on the tube or dial will be the *systolic pressure.* If the air in the bag is further reduced until the sound ceases to be heard, the reading at that point indicates the *diastolic pressure.* The *pulse pressure* is the difference between the diastolic and systolic pressures and normally is about 40 mm.

The *regularity* in rate and rhythm of the pulse varies as a result of the action of drugs, disease, and in accordance with the physical and mental condition of the patient. Usually the pulse rate rises at the rate of about 10 beats for every 1 degree of increase in temperature, though in some diseases the pulse beat may be high or low in proportion to the degree of temperature. A pulse is said to be *regular* when each successive beat is equal in volume, tension, and frequency.

There are several variations occurring in the rhythm of the pulse and the most common of these irregularities is known as *intermittent* pulse. Although the heart may not miss a beat, because of failure of the arteries to distend properly the pulse skips a beat. This intermission may occur at regular or irregular intervals, and while it may be due to a weakened heart or some condition of the arteries it frequently occurs in apparently healthy persons who are addicted to the overuse of alcohol, coffee, tea, or tobacco. However, when a pulse is irregular in rate, in rhythm, or in both, this irregularity generally is a symptom of serious disease, commonly of the heart. Beats may follow each other with great rapidity and then change to slow with perhaps an intermission, and at the same time a variation in force and volume may be present.

A *dicrotic* pulse (from a Greek word meaning double beat) is one which frequently occurs in typhoid fever and other diseases causing a depleted condition of the system. It is due to lack of tone of the walls of the aorta, whose natural rebound or recoil, normally not apparent, is so pronounced as to seem like an actual second beat of the heart. This recoil of the aortic walls is transmitted through the arterial system, and causes the pulse beats to seem divided, with the second part of the beat weaker than the first part. In

taking a dicrotic pulse the two beats must be counted as one in recording the pulse rate.

The *volume* of the pulse refers to its size and depends upon the force of the systolic contraction of the heart and upon the general physical condition of the body. Some of the conditions affecting the volume of the pulse are disease, exercise, excitement and emotion, the action of drugs, fatigue, and sleep. When the volume of blood flowing through the arteries is great the pulse is said to be *full*, and if at the same time the frequency of the beat is increased it is said to be *full and bounding*. Other descriptive terms used in connection with the volume of the pulse are *thready*, when the pulse feels like a little thread; *hard*, when the pulse is very small in volume but feels hard; and *small*, when the volume is lower than usual.

When taking the pulse the condition of the artery should be noted by gentle and careful digital examination while apparently taking the pulse. A normal artery feels round and elastic, and usually is firm. But if it feels twisted, or hard and unyielding, and gives one an impression that it is brittle, this information should be reported to the medical officer and recorded, as such conditions often are important symptoms of disease.

It is sometimes necessary to take the pulse in each wrist because of difficulty in obtaining an accurate count in one; and in certain conditions not often found, the pulse in one wrist is not the same as that in the other. The patient should be sitting or reclining so that, as a rule, the pulse may be taken at the radial artery, and his arm should be relaxed and supported. If the patient is excited, wait, if possible, until he is more quiet. Do not take the pulse with the thumb but use the middle or index finger, and hold it on the artery a sufficient time to determine the character as well as the frequency of the pulse beat. If unable to find or count the pulse in one location, try another; if not sure of the count, record it as approximate, and ask a more experienced person to verify it. In taking the pulse be accurate; *never guess.* The pulse should be counted for a full minute by inexperienced persons as should also always be done when the pulse is irregular or unusual in any way. When, from experience, one is thoroughly familiar with the method of taking a pulse and is accurate, a fairly good count may be made by taking the pulse for a quarter or half of a minute and multiplying the result by four or by two.

Respiration is the usually automatic action of breathing and consists of the the alternate expansion and contraction of the chest walls which causes the lungs to expand and contract. The expansion movement, by means of which fresh air containing oxygen is taken into the lungs, is known as *inspiration* and the contraction movement, which forces the air laden with carbon dioxide out of the lungs, is known as *expiration*. Respiration consists of one inspiration and its accompanying expiration and a period of rest between them. The respiratory movements are more or less under the patient's control and therefore should be counted without his knowledge. To do this, keep the fingers upon the pulse as though still counting it, at the same time watching the rise and fall of the patient's chest, thus counting the respirations for a full minute.

The rate of respiration is the number of expirations and inspirations counted as one which occur in one minute. The number per minute in the average healthy adult is usually from 18 to 24 per minute which is considered the *normal rate*, and any considerable deviation from this rate indicates some interference with the normal functions of the body.

When the respirations of a normal, healthy adult are uniform in depth and frequency, smooth and quiet, with no sign of effort or strain, they are

spoken of as *regular*. They may be temporarily increased or decreased in rate by exercise, emotion, sudden application of heat or cold, or by any sudden fear or excitement, but they quickly adjust themselves and return to normal. Respirations are termed *irregular* when they vary from the normal as a result usually of pain in the muscles or tissues associated with breathing, of disease or injury to the lungs, of undue pressure from the diaphragm caused by gas or fluid in the abdominal cavity, of weakness, shock, heat or cold, lack of air, or of an insufficient blood supply resulting from anæmia or hæmorrhage.

In recording the respiratory movements, notation should be made as to whether or not they are shallow or deep, regular or irregular, and whether or not the chest walls expand normally. Any difficulty in breathing, or labored breathing which usually is accompanied by rapid respiration should be noted. This condition may be caused by heart disease or by conditions of the lungs.

Dyspnœa is difficult breathing, accompanied usually by sound. In certain diseases the sound is of diagnostic value, being characteristic of them, as a grunting sound in pneumonia, accompanied by the moist, bubbly sound of bronchitis and asthma; crowing sounds and sharp rasping breath sounds in croup; stridulent (squeaky) breathing as in diphtheria; and sighing respirations as in severe hæmorrhage, and in collapse and shock, showing that the body is not receiving sufficient oxygen. (In case of hæmorrhage this is often accompanied by a definite gasping for air, called air hunger.)

The type of breathing known as *Cheyne-Stokes respiration* indicates failure of the respiratory center. It is characterized by respirations which begin quietly, but at each succeeding respiration become deeper and louder until a climax is reached; then gradually decreasing until this type of respiration ceases with a deep sigh. This is followed by an appreciable pause, after which the cycle is repeated. In the second type of this class of respiration, the respiration begins and proceeds in the same manner as in the first until the climax is reached, when there is a sudden, complete pause, after which the respirations go on as before.

Œdematous breathing is characterized by loud, moist, rattling râles, caused by air passing through fluid in the air sacs of the lungs. This fluid is the result of an abnormal infiltration of serum into the air sacs.

Singultus, or hiccough, consists of spasmodic inspirations suddenly arrested by an involuntary closure of the glottis. This is a serious symptom in a patient who is very ill.

Clinical recording and charting is preparing written records of the observations made by the attendant regarding the patient's physical and mental condition, of medications and treatments given to him, of nourishments taken by him, of his temperature, pulse, and respiration, of the number of defæcations, of the quantity of urine voided, of specimens sent to the laboratory for examination, etc.

Such written records are termed clinical records and their purpose is to provide the medical officer with information as to the patient's condition since last seen and afford him a means of comparing the patient's condition from day to day. They also serve as a guide to the medical officer in making diagnoses and ordering treatment, and their importance can be realized when it is remembered that the patient is seen by the medical officer for but brief periods each day, while he usually is continually under the observation of an attendant.

Clinical records can be kept indefinitely for reference, are often used in making statistical and similar compilations and are of value as evidence in legal actions.

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In preparing clinical records it is essential that they be correct in every detail, that the facts reported be true, that nothing of importance is omitted, and that the words used definitely describe what is observed. Therefore, the primary requisites of clinical records are *accuracy* and *completeness.* It is desirable that only objective information should be recorded although the subjective symptoms complained of by the patient are sometimes noted. In recording *what is observed* care must be taken to see that the entries do not express any opinion of the observer as to the condition of the patient, as improved or not so well. The entries on clinical records should be legible so that there can be no question as to the meaning of the words or figures used, and they should be neatly arranged and spaced, without erasures.

The statements entered on clinical records must be accurate, as brief as is consistent with furnishing complete information, and free from ambiguity. If things have not been weighed or measured the approximate amount, designated as such, should be given.

Each observation should be recorded in a separate paragraph, and record must be made of all objective symptoms noted and of subjective symptoms as necessary. Records of all medications and treatments with the time given must be made, but no medication should ever be entered on a record until after it actually has been given. If medication is given to relieve conditions which should be ameliorated in a short time, record the result and state the time elapsing before the drug or treatment was effectual. When recording baths that might have a bad effect, state something concerning the patient's condition during the time. When recording the result of irrigations, douches and the like, state whether or not the flow was clear or contained foreign matter. When making records of the dressing of an open wound make a note of the presence or absence of discharge, and the nature of it, if present, also the general condition of the wound. If a medical officer or any one other than the attendant dresses the wound ask what record should be made. If a patient vomits, record the approximate amount, its color, and any noticeable characteristics. Observe and record with especial care the nature of all excreta, and any discharge from diseased parts (sputum, when trouble is in the lungs or bronchi; the fæces, when the trouble is in the stomach or intestine; the urine when the trouble is in some part of the urinary tract, or metabolism is at fault). When it is necessary to measure the urine voided it is also necessary to measure the fluids given and to record the amounts taken.

Unusual symptoms should be promptly reported to a superior and recorded in sufficient detail; for instance, the time the first symptom was noticed and what it was, whether pulse rate, color, expression, appearance of blood; whether a visible external hæmorrhage, or an internal hæmorrhage recognized only by symptoms other than visible blood. Be absolutely sure of all signs and symbols used.

The **clinical or temperature chart** (N. M. S. Form Q) should be started for every patient upon his admission to the ward, and should be kept complete and up to date until discontinued by the medical officer. Each page should be numbered and should contain the complete heading data of the first page—name in full, rating, diagnosis, race, religion, and age. The year and month, the day of month, and day of disease or days after operation (post operative), should be recorded in the space allotted to them. Spaces marked "A. M." and "P. M." are provided for recording the time temperature, pulse, and respiration are taken; and at the bottom of the sheet are spaces to record the urine voided or catheterized; also movements of the bowel, whether natural or as a result of an enema. The main body of the sheet is divided into small

oblong blocks, separated vertically by dotted lines, horizontally by continuous lines. The top third is for recording temperature, the second section for the pulse rate, and the lower third for the record of respiration. A heavy black line drawn horizontally through each section at a certain place indicates normal for each. The temperature is indicated by a dot made in the block opposite the temperature index, marked in figures at the side of the chart. The sections of the divided vertical lines correspond to the divisions on the scale of the clinical thermometer, the space between each two representing 0.2° F. The record dot should be made in the open space of the block, not on the lines. These dots showing the rise and fall of the patient's temperature should be connected by lines drawn straight between them with the aid of a ruler; thus the whole course of the fever accompanying the ailment may be readily followed from its start to its finish.

In the same manner in the lower sections provided for their recording, the increase and decrease of the respiration and pulse rate should be made. When the temperature is taken any other way than by mouth, the word "rectal," "axilla," or "groin," depending upon where taken, should be noted in red ink above the record dot. The temperature, pulse, and respiration record should extend from 8 a. m. to 8 a. m. The record for 24 hours should be divided from the preceding 24-hour record by a red line drawn vertically before the beginning of each daily record. If customary or desired, the day may start at midnight, in which case the red dividing line should be drawn there.

N. M. S. Hospital Form No. 17, entitled **Clinical Notes**, should be attached or placed directly beneath the clinical chart. In the use of this record the blank spaces at its top should be fully filled in with the data required, and in the columns headed date, hour, nourishment, and treatment should be recorded the appropriate information. In the column headed remarks, orders of the medical officer with their apparent results, necessary details of unusual variations in temperature, pulse, and respiration, information concerning the voiding of urine (with the amount) and of defæcations, a record of the amount of fluid intake, and the symptoms observed by the attendant may be recorded. In cases where a 24-hour total of fluid intake and output is required, such totals are also entered in the column under remarks. Such a record is for the purpose of keeping the medical officer informed as to the fluid output in comparison with the fluid intake, and if proper elimination is taking place, the totals should approximate. In cases of diabetes, nephritis, or other conditions where special medications from which a regular increase or decrease in quantity of urine is expected, a similar 24-hour summary is made, giving the total amount of food with its caloric and other property values; and the total amount of medicines administered (as for instance, insulin), the highest and lowest temperature, pulse, and respiration, and a concise, general summing up of all important items of information. Such summaries must be accurate, for upon them depends decision as to the patient's condition and his future treatment. This special record is divided from the preceding and following daily records by double red lines so that this important information may stand out by itself, and thus be referred to easily and compared with other similar records.

N. M. S. Hospital Form No. 59, the **Clinical Record**, is prepared by the medical officer and is attached or placed next beneath the Clinical Notes.

Reports of laboratory, X-ray, and other special examinations are also attached to the patient's clinical records. These records combined are sometimes termed "case papers," and upon discharge of a patient from a naval hospital become a part of the permanent files of the hospital.

The **collection of specimens** from patients for examination is a very important detail. The collecting is usually done by a hospital corpsman and upon his conscientiousness and sense of responsibility the proper performance of this very important detail depends. The object of collecting specimens is to assist in diagnosis, to help determine the progress of the disease with which the patient is suffering, and to furnish information regarding the results of the treatment employed. Specimens are examined by general appearance and by chemical and microscopic methods.

Certain general precautions should be followed in the collecting of specimens and it is essential that they be so marked that they cannot be confused with other similar specimens. Never use a cracked receptacle. Collect the specimen in the right receptacle, use the right label, send the right amount; collect and send in proper manner at the right time, to the right place in the laboratory. Have the receptacle thoroughly clean (sterile when so required), and well stoppered to avoid contamination from outside. When collecting specimens allow no opportunity for the patient to deceive, as one wishing to seem more or less ill than he really is might get another patient to void, expectorate, or produce some other specimen for use. When preservatives are used in specimens state the kind and amount used on the laboratory request blank. Make a notation on the clinical notes when a specimen has been sent to the laboratory, stating the date, hour and nature of specimen, and examination desired. With all specimens send the routine laboratory request blank properly filled out. *Never* leave unsightly specimens in the ward, nor *uncovered* in the lavatory; but when necessary, while further collection is being made, keep properly covered in an isolated place in the heads or lavatory. Always take specimens to the laboratory at the earliest possible time.

There are various designations for urine specimens, such as a *routine specimen, sterile specimen, catheterized specimen, 24-hour specimen,* and a *"stat"* or *immediate specimen.* A routine specimen of urine is collected at a single voiding and is sent to the laboratory from each new patient the morning following his admission to the hospital. On the morning preceding, and the morning following the administering of a general anæsthetic a routine urine specimen (preoperative and postoperative) is sent to the laboratory, and for other cases when ordered by the medical officer or surgeon. The specimen must arrive at the laboratory at the time specified by the routine regulations of the hospital.

Sterile specimens of urine are collected without catheterizing the patient in the following manner: Have sterile container with sterile stopper. Bathe the patient's genitals and pubic region thoroughly with soap and water, remove all traces of soap, then bathe the parts with 3 per cent boric acid solution. Instruct the patient to void into the sterile container, rendering him all necessary assistance. Replace sterile stopper which has been kept uncontaminated; mark specimen "sterile," in addition to filling out request blank in routine manner, and send it to the laboratory.

A catheterized specimen is obtained by following the preliminary procedure for a sterile specimen except that instead of being allowed to void the patient is catheterized.

A 24-hour specimen contains the total amount of urine voided by a patient in 24 hours. The purpose of this particular specimen is to determine the total normal constituents and the total abnormal constituents. It is collected in a sterile wide-mouthed jar (if a preservative is to be used the designated amount is put in the jar), properly covered or stoppered with a sterile or absolutely clean cover. This container must be kept in a cool place. Unless otherwise

ordered, start the specimen in the early morning so that it may be completed the following morning and ready for delivery to the laboratory at the routine hour. On the evening before the specimen is to be started prepare and properly label the jar and place it in a designated place, instruct the patient in regard to the required procedure. Tell the patient to void on first waking (if he does not wake early enough the night attendant, unless otherwise instructed, should awaken him); discard this first morning voiding, making a record of the time and date, and a statement that a 24-hour specimen was started. From that time until the following morning at the same time save all urine voided, including that voided at the time of completing the specimen, in the receptacle prepared for it. If the patient is a bed patient the attendant must take care of the collection, but an "up patient," with proper instructions and supervision may collect his own. As an example: The patient voids at 6 a. m., which urine is thrown away, but all urine voided subsequently, up to and including 6 a. m. the following morning, is saved. Depending upon instructions and the routine regulations of the laboratory, the entire specimen is sent to the laboratory where it is measured and examined; or a specified amount is taken from the well-mixed 24-hour amount, which has been measured, is properly labelled and, accompanied by complete data concerning the entire specimen, sent to the laboratory in a routine receptacle. The remaining urine is thrown out, the jar cleansed, sterilized, and made ready for use at another time.

When collecting urine for the *phenolsulfonepthalein kidney-function test,* the patient should be required to completely empty his bladder. One cc of phenolsulfonepthalein is then injected into the lumbar muscles of the patient, one glass of water is given to him to drink, and he is instructed not to urinate for one hour and 10 minutes, at which time he should void as much urine as possible. This is placed in a bottle properly labeled and designated as first-hour specimen. One hour later the patient voids again, and this specimen is placed in a second bottle and marked second-hour specimen. Both specimens are then taken to the laboratory with the request clearly expressed on laboratory request blank. It is absolutely necessary that the bladder be completely emptied at the time the injection is given, so that the urine collected during the test may tell a true story. Full directions accompany the ampules of the drug, which should be given only under a medical officer's order and supervision.

Special precautions must be taken in collecting **specimens from the throat** for cultures and smears. The stopper and the edge of the test tube should be passed through flame before the swabs are removed from the sterile tube and again before they are replaced in the tubes or applied to the media. This will prevent contamination from outside bacteria. Sterile stoppers should be replaced in test tubes while culture or smear is being taken.

The following articles are required in making throat cultures and smears: Sterile test tubes with sterile swabs, sterile culture tubes containing media, matches, an alcohol lamp, a flash light, tongue depressors, gauze wipes, and a kidney basin in case the patient gags or vomits. Throat cultures and smears are taken as follows: Place the patient in a sitting position, if he is able; otherwise in the next best position for obtaining the specimen. Instruct him to relax his lower jaw and to draw his tongue flat by suction, breathing through his mouth in slightly panting fashion to lessen the tendency to gag. Flame the edge and stopper of the sterile tube to prevent contamination of the sterile swab while removing it from the container. While an assistant holds a flash light in a manner to well illuminate the patient's throat depress the patient's tongue with a tongue depressor held in the left hand and, holding the sterile

swab in the right hand, make a thorough swabbing of the affected areas of the throat, mouth, or gums, working quickly but gently. In the case of a culture use the swab, then apply it immediately to the culture media and return the swab at once to a plain sterile test tube. In placing the culture material great care must be taken to pass the swab gently over the culture media to avoid breaking its surface. At once break in two the tongue depressor used and place it in a receptacle for burning. Flame the edge of the tube before replacing the sterile stoppers. Affix proper labels to the tubes and take the specimens to the laboratory without delay.

The same care and precautions should be taken in procuring specimen **cultures and smears from wounds** as in obtaining other cultures and smears.

Detailed instructions for procuring specimens for **gonorrhœal smears** usually are given by the medical officer in charge of such cases or by some other competent person designated by him. The same general precautions, however, apply. Special precautions should be taken by the attendant when procuring such specimens to prevent infecting himself and to carefully protect his eyes from this virulent infection, which often causes blindness.

Specimens of **bone fragments, of diseased tissue, abnormal growths, fluids,** etc., which are obtained during an operation or dressing should be placed in sterile containers and, with laboratory request blank properly filled out, sent to the laboratory. Such specimens always should be saved, even though no order for examination has been given, until the medical officer or surgeon has been questioned in regard to them. Valuable specimens are sometimes lost by disregarding this wise precaution and important investigations retarded.

When specimens of **stools** which are to be examined for typhoid, cholera or tubercle bacilli, or other microörganisms of an actively infectious nature are collected they should be handled with extreme care in order to keep the cover and outside of the container free from particles of the specimen and to prevent infecting the ones who handle them.

A specimen of **sputum** should be collected in this manner: Prepare and properly label the specimen box or container the night before, giving the patient any necessary instructions. Be sure the container is clean; use no disinfectants. Have the container, usually a Petri dish, sterile when a sterile specimen is ordered. In the early morning before breakfast have patient rinse his mouth well with *plain water*, expectorating with this all excess of saliva; then instruct him to cough as deeply as possible in order to obtain a specimen from the bronchi or the lungs to expectorate directly into the sputum cup or dish, taking care that none is deposited on cover or sides of the container.

General care and comfort of the patient.

Although nursing usually is considered as consisting almost entirely of caring for the disease or condition with which a patient is suffering, it is a fact that but little time is so spent by the nurse. Actually, much more time is spent on measures which have for their object the promotion of the physical comfort of the patient and which help to maintain his strength and resistance. Those measures are chiefly concerned with his personal cleanliness, his nourishment, elimination, and rest.

In promoting the physical comfort of a patient it should be remembered that his mental attitude has a marked influence on his physical condition. It is therefore important that every effort be exerted to keep a patient in a cheerful frame of mind, as contented as possible, free from worry or fear as to his condition, and from becoming depressed. Confidence in the medical officer and attendants and a generally hopeful attitude favorably affect the physical condition

and their maintenance is most desirable. It is necessary that such efforts of the attendants be suited to the temperament of the individual patient and that they be made in the way that is most likely to obtain the proper response. To do this requires considerable understanding of the patient, his likes and dislikes, his strong points and his weak ones, and it must never be forgotten that a sick person reacts differently than a well one and is affected by things that ordinarily would hardly be noticed.

The bed, when neatly and correctly made, is a most important factor in the comfort of a patient. It must be clean, comfortable, and fitted to the needs of the patient, and should have a good mattress and good pillows. Its appearance, furnishings, accessories, and agreement with other furniture are of secondary importance.

A hospital bed usually is higher and narrower than the average one found in a home, and this fact contributes greatly to the efficacy of the care and treatment of a patient, as it makes it easier for the attendant to care for the patient. The mattress should always be protected with a linen or cotton mattress cover, made to fit the mattress as closely as possible in order to prevent surface soiling. This cover may be laundered easily and should be changed frequently. From time to time the mattress should be turned, always from end to end which changes the points of greatest pressure; when turned from side to side this is not accomplished. Two pillows should be allotted to each bed, one soft, and the other a hard, or hair pillow. The hard pillow is placed under the soft pillow to aid in support and elevation. In cases of high fever the soft pillow often is removed as the hair pillow is cooler, allows better circulation of air about the head and shoulders, is nonabsorbent, and is less easily impregnated with odors. Pillows of various shapes and sizes are used for special support in cases of serious illness, helplessness, and for obtaining immobility. They usually have an inner *cover* as well as an outer *case*, and whenever necessary an inner rubber cover should be used inside the outer case for protection of the pillow.

The mattress and lower sheet of all beds for strictly bed patients are protected by a rubber draw sheet which should extend from several inches under the lower edges of the pillows to several inches below the patient's knees, and should be long enough to tuck under the mattress about 8 inches on each side. As rubber should never be allowed to come in direct contact with the patient the rubber draw sheet is covered with a cotton draw sheet which should extend about 2 inches above and below the rubber draw sheet. When necessary the entire mattress is covered with a full-length rubber sheet.

Correct **bed making** is one of the first things that should be learned by those caring for the sick or injured. Loose and sagging beds should not be used and special care should be taken to prevent bed coverings from becoming too tight for the patient's comfort. Whenever a patient is temporarily out of his bed it should be straightened and smoothed before his return.

The fundamental principles of bed making are the safety and comfort of the patient, the warmth, cleanliness, and tightness of the under linen, and protection of the mattress.

Bed linen should be changed as often as necessary but economy in its use should be practiced, and badly stained linen should never be used. The under and draw sheets should be drawn tight to prevent the formation of wrinkles under the patient which makes possible the development of bedsores. There should be sufficient covering to keep the patient warm and, while it is necessary to have the bedclothes look neat and tight, care should be taken to avoid the causing of pressure sores on the toes.

Beds and bedding should be kept free from vermin. If signs of bedbugs appear the bed should be cleaned with a disinfectant solution, the bedding sterilized, and the mattress thoroughly brushed with kerosene and put in the sunlight for 48 hours.

The proper method of making a bed is to obtain all the necessary bedding, put it in a place convenient to the bed, remove all clothing which may be on the bed and turn the mattress from top to bottom. The mattress cover should be placed over the mattress from head to foot, corners neatly fitted and the tapes tied at the foot of the mattress. The bottom sheet should be placed on the mattress right side uppermost with the wide hem at the head of the bed, the small hem even with the bottom of the mattress, and so arranged that it hangs equally over the sides of the mattress. The wide hem should be folded under the head of the mattress and tucked in with envelope corners at each side. The sheet is then pulled down to the foot of the bed, made taut, and the sides tightly tucked in. The top sheet is placed on the bed wrong side uppermost with the wide hem toward the head of the bed and even with the upper edge of the mattress. It should be so placed that it hangs equally over the sides. The end is folded smoothly under the foot of the mattress, envelope corners made and the sheet freed from wrinkles. Next the blanket is placed on the bed in such a manner that it hangs equally at the sides and is 6 inches from the head of the bed. The blanket then is folded over the foot of the mattress, tucked in, envelope corners made, and the entire blanket freed from wrinkles. The upper part of the sheet extending beyond the blanket should be folded back over it and tucked in tightly at the sides. The spread next is placed in such a manner that it will be right side uppermost (anchor pointing to the lower left corner of the bed), hanging equally at the sides and should be tucked in at the foot just enough to make corners. All excess goes to the top. This protects the under sheet and keeps it free from dust. Pillow covers and cases are applied to the pillows, arranged in such a manner that the corners are well filled, and then placed at the head of the bed with the seam to the back and the closed end toward the entrance of the ward.

A bed should be **cleaned and aired** weekly on specified days; after the death or discharge of a patient; in case vermin are found in the bed; and after use by a patient having a communicable disease. The approved method is as follows: Brush the mattress thoroughly with a whisk broom moistened in disinfecting solution, giving special attention to the tufts, seams, and bindings. Examine the mattress for rips, stains, and vermin; remove the stains, have it repaired if necessary, and if vermin are found proceed as previously directed. Remove the mattress from the bed and place it on the mattress-airing rack, if one is available. If such a rack is not available it should be placed on two ward chairs out of doors. A mattress should be sunned for 48 hours if possible, as it is when vermin have been found. Thoroughly wash and dry the frame of the bed.

The purpose of **making a bed with the patient in it** is to obtain cleanliness with the least possible discomfort to the patient. Place all necessary clean linen in order on the bedside locker, arranging chairs at the foot of the bed to receive the soiled linen and to hold the pillows while airing. Loosen all bed linen, remove both pillows, unless by so doing the patient is made too uncomfortable, in which case remove one and place on the chair to air. Remove the spread by taking hold of it by the top and bottom hems. This will fold the spread in half. Fold again from side to side and place on a chair. If there are two blankets on the bed remove one in the same manner

as the spread. Next place a clean sheet, wrong side up, wide hem at top, over the remaining blanket, and on top of the clean sheet replace the blanket previously removed, turning down the sheet over its top edge 12 inches. If the patient is not too ill instruct him to hold the upper edge of the clean bed clothes while the soiled sheet and remaining blanket are removed; otherwise tuck them in about his shoulders and, while standing at the foot of the bed, reach under the clean sheet, grasp in turn the blanket, then the sheet, remove and fold them in the same manner as the spread, and place on a chair to air. Fold back the side of top sheet and blanket over the patient, leaving the fold wide enough to cover his back when he is turned or lifted to the far side of the bed, then turn or lift the patient to the opposite side of the bed. To change the under sheet and draw sheet, the under sheet is folded or rolled lengthwise close to the patient's back and a clean sheet folded or rolled lengthwise to its middle and placed close up to the soiled sheet. The upper corner is then made and the sheet tucked in the entire length of the bed. The patient is turned on his opposite side, the soiled clothes removed, the clean sheet freed from wrinkles and tucked in at the head and side to make it taut. If a drawsheet is present it should be removed with the soiled sheet and a clean draw sheet folded or rolled and placed in its correct position at the same time and in the same manner as the lower sheet. If it is impossible to turn the patient upon his side, assistance should be obtained. The head, shoulders, body, and hips are supported in that order while the soiled sheet is folded or rolled and gradually removed from head to foot, following it up with a clean sheet which has been rolled or folded and which is unrolled or unfolded as the soiled one is withdrawn. The sheet which has been airing, if sufficiently clean, may be used for the draw sheet or if a draw sheet is not on the bed use this former top sheet for the bottom. Replace the extra blanket if needed and put on bedspread, being sure it is under the 12 inch fold of sheet at the head of the bed. All top bedding should be tucked in only enough to hold the covers. In all ordinary bed making each piece of linen should be tucked in separately when the corners are made.

In **changing the lower sheet of a bed patient** it is necessary to loosen all of the clothing from the head, foot, and sides of the mattress, and to remove the pillows and all upper clothing except the sheet. The patient then is turned on one side. The lower sheet is folded or rolled lengthwise close to the patient's back and a clean sheet folded or rolled lengthwise to its middle and placed close up to the soiled sheet. The patient is turned on his opposite side, the soiled clothes removed, the clean sheet freed from wrinkles and tucked in at the head and sides to make it taut. If a drawsheet is present it should be removed with the soiled sheet and a clean drawsheet folded or rolled and placed in its correct position at the same time and in the same manner as the lower sheet. If it is impossible to turn the patient upon his side, assistance should be obtained. With an assistant on the opposite side of the bed, it is possible to loosen the clothing all around, and to remove the pillow. The head, shoulders, body, and hips are supported in that order while the soiled sheet is folded or rolled and gradually removed from head to foot, following it up with a clean sheet which has been rolled or folded and which is unrolled or unfolded as the soiled one is withdrawn.

Changing the mattress with the patient in bed may be accomplished as follows: The spread should be folded neatly and placed on a chair. The sides of the upper sheet and blanket should be folded over the patient, and the bottom part of it folded under the legs. The pillows should be removed, the lower sheets loosened and the sides of the sheets including the rubber sheet

rolled close to the patient. One side of the rolled sheet then should be pulled, drawing the patient toward the attendant's side of the mattress, an assistant should stand on the opposite side of the bed and draw the mattress toward his side until half of the springs are exposed. This exposed part is covered with a fresh mattress, the patient drawn upon it, the old mattress discarded and the fresh mattress pulled into position. The patient should be drawn toward the center of the bed, and the making up of the bed continued. If the under sheets are to be changed, the vacant half of the mattress should be covered with fresh linen, and before the patient is drawn to the center of the bed, the patient lifted (with some assistance) onto the clean side, the soiled linen removed, the clean sheets drawn over the remainder of the mattress, and the making of the bed completed.

Turning the mattress with the patient in bed may be accomplished in a manner similar to changing the mattress, except that after drawing the mattress to one side of the bed, the springs should be covered with three pillows and the patient lifted on to them. The mattress then is turned top to bottom, the patient lifted on the mattress, and the bed made up as before.

Beds sometimes are prepared to take care of certain classes of patients and are then given names according to the purpose they serve. Two such types of beds are known as ether and fracture beds.

The fracture bed differs from the ordinary bed in that perforated boards, a frame of slats, or a number of slats running from side to side of the bed are placed between the springs and the mattress, or between the springs and the frame of the bed. The object of a fracture bed is to prevent any motion at the point of fracture by reason of sagging of the mattress.

The **ether bed**, also known as an anæsthetic bed, is prepared especially for patients who are or have recently been anæsthetized. The object of an ether bed is to provide for easy accesibility, extra warmth, and the safety and comfort of the patient. In making an ether bed the following equipment is required: Two old blankets, 1 pajama coat, 1 hand towel, 1 paper bag and safety pin, 4 hot water bottles with covers, and necessary shock blocks. On the bedside locker should be placed a mouth gag, 2 pus basins, a quantity of gauze wipes, paper and pencil, and a small clock with second hand or a watch with a second hand.

The procedure in **making an ether bed** is as follows: First make the bottom of the bed as for any bed patient, that is, with a draw sheet; over this place an old blanket crossways on the bed, the side even with the end of the mattress, and tuck in on both sides; next take a rubber and linen drawsheet and place them on the upper part of the bed being sure that they cover for about 2 inches the bottom draw sheet; then take the second blanket and place it on the bed even with the top of the mattress; make the first part of the corners at the bottom but instead of finishing them fold the edges of the blanket toward the center of the bed. In one side of these folds place a pajama coat. Under the top blanket place three hot water bottles, one each at the foot, middle, and top of the bed. Next put on the top bed covers in the usual order, and fold fan-like to the foot of the bed. Place a hand towel across the head of the bed to protect the bedclothing after the patient returns from the operating room. Tie the pillow securely to the head of the bed with gauze bandage to protect the patient's head from drafts. Place shock blocks at the foot of the bed and move the locker behind the bed after placing the proper articles on it.

A screen should be placed around the bed after the patient has been placed in it, the room should be kept warm and well ventilated, the patient should

never be left alone until after reaction from the anasæthetic is complete, and his pulse and respiration should be taken every 15 minutes and recorded.

After being placed in bed an ether patient should be kept well covered and the hot water bottles used to warm the bed removed, unless otherwise ordered by the medical officer, in which case they should be placed not nearer than 8 inches to the patient with a blanket in addition to the cover between them and the patient. Hot water bottles used in an ether bed should always be examined to make sure they do not leak. Chilling of the patient by exposure or by a damp bed may cause ether pneumonia.

Shock blocks, or bed blocks as they are sometimes called, are solid cubes of wood about 6 inches square, the depth or height varying according to requirement. In the middle of the top a hole is bored large enough to receive the end of the bed legs and deep enough to hold them without danger of slipping. The purpose of the bed blocks is to elevate the head or the foot of the bed in case of drainage, shock, or hæmorrhage, and to facilitate giving certain kinds of baths, as a spray or shower bath, in bed. When using bed blocks care must be taken not to jar or jolt the patient while raising the bed; and both blocks must be of the same height so that the elevation will be uniform. If the bed is elevated at the foot the patient's head must be protected from slipping against the bed bars by securing a stiff pillow on the inner side of them, and when permissible, raising the knee support of the Gatch spring.

It is essential in caring for bed patients that the attendant understand the methods of changing their clothing and moving them.

When **changing the clothing of a helpless or unconscious patient,** if the sleeves do not slip off readily, one hand should be slipped through the armhole, the patient's arm grasped above the elbow, bent slightly, and gently drawn backward, while with the other hand the sleeve is removed by pulling the armhole or the wrist. If the arm is injured, the sleeve of the injured arm is removed last, but in putting on the pajama coat, the injured arm is put in first. The pajama coat should be pulled well down in the back in order to avoid wrinkles. In the case of helpless and unconscious patients it is better to have the pajama coat buttoned in the back. The most efficient way to remove a coat from a helpless patient is to draw it well up to the shoulders, then bring it over the head, taking out first one arm and then the other. The trousers are pulled down to the ankles, both legs are lifted with one arm, and the trousers removed with the free hand. If the leg or foot is injured or swollen the trouser leg should be cut at the seam to facilitate repair later.

Before **moving and lifting a patient** he should be drawn to the edge of the bed, thus minimizing the degree of stooping required. When stooping is unavoidable, the lifter should bend his knees and hips, throw back his shoulders and retain them in that position. Before lifting, the patient should be instructed to make himself rigid, and to remain so while being lifted. When two or more persons are lifting a patient, it should be done in unison, one directing and giving the word to start when ready, but when carrying a patient one carrier should step off with the right foot and the other with the left, to prevent swinging.

In moving a helpless patient to the side of the bed, his head and shoulders should be supported with one arm and the other arm gently placed under the small of his back. The assistant standing on the same side of the bed should pass one arm under the upper part of the patient's thighs, and the other under his knees. The patient thus can be lifted easily to one side of the bed. A heavy patient may be turned or moved more easily by loosening the draw-

sheet and pulling him with it to one side of the bed, or by grasping the loosened end of the sheet on a line with the shoulders and thighs and then gently pulling it upward and turning the patient on his side.

A weak or helpless patient should be turned on his side by placing one arm under his far shoulder, obliquely across the back in such a manner that the hand comes under the patient's near side; the other arm should be placed under his hips from the far side, the patient raised slightly and drawn somewhat backward, and turned toward the attendant. It may be necessary to make some change in the position of the patient's shoulders or hips. In moving the shoulders of a helpless patient the attendant's arms should be placed on either side of the patient's body, bringing the hands under the lower arm, then the patient should be raised slightly and moved as required. The hips should be moved in the same manner.

As an aid in moving an extremely heavy or quite helpless patient the draw sheet may be loosened at the sides and the ends rolled or folded back close to the patient's body. With an attendant at each side of the bed grasping the ends of the draw sheet the patient may then be easily raised and lifted toward the head of the bed. If the patient is too weak to support his head as he is lifted, a pillow may be left under his head and the draw sheet extended far enough under it to support the head, or, the lifters may support the head and shoulders with one arm while with the other hand they grasp the gathered end of the draw sheet and lift the buttocks.

In **turning bed patients** they may be turned either from or toward the attendant. To *turn a patient from him* the attendant should place one arm under the patient's shoulders, the other well under his hips, while firm pressure is made against the near shoulder and, with his hands at the axilla and hips on opposite side of patient, lift him slightly and roll him over gently taking care not to roll him too far and out of the bed. The body should be in a position with a slightly forward cant, the under leg drawn back and the upper leg forward, with one pillow placed between the knees and one snug to the back for support, if necessary. The patient's under shoulder should be brought back slightly, and the pillow arranged in the position required for support and comfort, drawing the under arm backward or forward to suit the comfort of the patient and to prevent pressure. To *turn a patient toward him* the attendant should put one arm over the patient with his hand well down under the patient's shoulder on the opposite side, and place the other arm over the patient's hip, the hand well down under the opposite hip. The patient should then be lifted slightly and rolled gently toward the attendant, after which he should be adjusted comfortably as described before.

As a rule when **transferring a patient from a stretcher to a bed** three attendants are required, although two will suffice if the patient is not too heavy and has no serious injury. The upper bed covers should be fan-folded to the foot of the bed and the stretcher placed at right angles to the bed. One attendant or lifter should place his arms under the patient's shoulders, one elbow supporting the head and the other arm extending well down on the back. The tallest and strongest should stand in the center, passing one arm under the hips, the other under the thighs, while the third keeps the lower legs from dangling or striking the foot of the bed. At a given signal all three should take firm hold of the patient's body and lift, turn, and place him gently on the bed, lifting him well up in bed and arranging the covers. In a room too small to place the stretcher at right angles, it may be drawn close to the side of bed, and while the three lift the patient, another person may withdraw the stretcher before the patient is placed on the bed. Sometimes the stretcher is brought

only to the door of the room and the patient carried from there to the bed. Patients should be transferred from the bed to the stretcher in the same manner, except that, as the stretcher is lower than the bed, he must be lowered rather than lifted into place. In both procedures the patient should be well covered during the transfer, a blanket being wrapped about his feet and shoulders and tucked up and in at both sides for protection of the patient and to prevent dangling ends which might catch and drag, or trip the lifters. The following precautions should be observed: Not to stumble, jar, or jolt the patient; not to squeeze or pinch a fold of flesh, or drop a patient on the bed, but to gently place him there; and not to allow the stretcher to roll or slip.

When **getting a patient up out of bed** caution should be taken to avoid exhausting the patient by permitting him to stay up too long at a time; to watch his color, pulse, and general appearance for signs of weariness and weakness; to prevent chill or overheating by placing the patient in a shady spot during hot weather and in the sunshine during cool weather; to watch out for wrinkles in the chair fittings, and to observe for pressure spots; to have the bedside table with call bell, drinking water, reading matter, etc., conveniently within reach of the patient, and to make certain that the chair is so placed that it will not tip or roll. The important points to remember are: When possible always roll the wheel chair to an outside porch in order that the patient may have the benefit of a complete change of environment and scenery, the direct rays of the sun, pure fresh air, and freedom from the sight and sound of acutely ill and suffering ward neighbors. When a porch is not available, a sunny window or sun parlor with the best possible view should be selected. One should not wait for the patient to complain of weariness before returning him to bed, but at the end of a reasonable period or at the first sign of weariness he should be put back to bed. As the patient gains in strength he may sit up longer. If the patient is unable to stand or walk, or is heavy, two assistants are required to lift him; one should raise and turn the patient so that his legs are over the side of the bed, then, standing one on each side of the patient, both lifters should place their arms in the position for raising a patient in bed, arms of patient resting across their shoulders, and lift together and place him carefully in a wheel chair. When the patient is able he may stand beside the bed, and, with the aid of an assistant, take the few necessary steps to the chair, which must be carefully steadied as he is assisted into it. Care should be taken that all rugs and furniture are out of the way, that the foot rest of the wheel chair is turned up until the patient is safely in the chair when it may be properly adjusted; that some one holds the wheel chair, or that it is placed firmly against something to prevent its rolling or tipping over while the patient is being placed in it.

A most important duty of an attendant in a ward is in **remedying the physical discomforts** of which patients complain. A number of the things which can be done to attain this end are here briefly mentioned. Lights should be properly shaded and the position of the patient and his bed such that his eyes will always be protected from the glare. All duties in the ward should be performed systematically, with no unnecessary noise or confusion, and voices should be quiet and gentle. Heating and ventilation should be properly regulated so that there may be uniform temperature and no drafts. Damp linen should be changed and profuse perspiration and body odors removed by frequent bathing and alcohol rubs, powdering between contiguous parts or in between folds of flesh, and when necessary, placing small pads or pieces of soft linen compresses between two adjacent skin surfaces. Excessive body temperature is relieved by cool sponges, by ice cap to the head, and copious fluid intake. A

restless, weary, or apprehensive patient may be reassured and calmed by quiet, encouraging conversation, hot or cool drinks, baths or alcohol rubs, and attention to voiding and bowel movements. Frequent inspection should be made of all appliances, splints, bandages, etc., the position changed, and any point of pressure massaged and given an alcohol rub at frequent intervals to aid in giving general comfort to the patient and to prevent bedsores. Necessary articles for patient's own use, call bell, drinking water, etc., should be placed within easy grasp that he may suffer no strain or danger of fall by having to reach for them. The patient may take some measure of exercise by change of position, flexing and extending arms and legs, actively or passively, and by at times lying without a pillow and with neck muscles relaxed, slowly rolling head about to relieve strain of cords of neck. The strength of a weak patient should be saved by guarding against exertion on his part, and by moving him no more than is necessary for his safety and comfort. Some one should feed the patient who is unable to feed himself, and should be on hand when the tray arrives. Slight gastro-intestinal disturbances may be relieved by drinks of hot water, application of hot-water bag to the gastric area, or by the insertion of a rectal tube. Copious drinks of hot water the first thing in the morning often render a cathartic unnecessary. Sleeplessness may often be guarded against by making sure that the patient is properly nourished, is neither too hot nor too cold, and by making certain that he is not annoyed or frightened.

As many of the procedures taken in the general care and comfort of the patient not only improve his comfort and sense of well-being but actually tend to support his strength and resistance they may well be designated as **physical supportive measures.**

The first, and perhaps the most important of the supportive measures to be now considered, is the *cleanliness of the patient*, which includes his bathing and the care of his mouth, teeth, hair, and nails. Cleanliness is essential to the health of anyone but it is especially so to one who is sick or injured. In many cases, particularly when the patient must remain in bed or cannot help himself, much of the work involved in maintaining his cleanliness must be done by the nurse.

For convalescent patients and those who are not very ill the **care of the mouth and teeth** should consist of the same cleansing that is required two or three times daily by well persons. Those who are able should do this themselves, the necessary articles being brought to the bedside and later removed. Patients who are ill with high fevers, however, require special attention and faithful care as, with a high temperature, there is likely to be an insufficiency of the secretions of the mouth which in health tend to keep the mouth moist and clean. If such secretions are absent for any length of time the gums and mucous membranes of the mouth and throat become irritated, the lips and tongue become dry and may crack, and only the greatest care will prevent the appearance of either sordes or herpes, which in turn may develop into serious complications. *Sordes* is an accumulation of food residue, dried epithelium, mucus, and bacteria. If allowed to accumulate it quickly becomes adherent to the teeth and often the mucous membrane is torn in efforts to remove the sticky, tenacious substance. These abrasions frequently become infected and cause complications such as sinusitis and mastoiditis. *Herpes* is an inflammatory affection of the skin or mucous membrane that is characterized by groups of small vesicles on an inflamed base. When herpes appears on the lips it is often spoken of as "fever blisters" or "cold sores" and the vesicles may become infected and form painful ulcers.

A fever patient's mouth should be washed after every feeding whether the food is fluid or solid, both at night and during the day. The following are often used as mouth washes: Dobell's solution; Liquor antisepticus, N. F. and Petrolatum liquidum, U. S. P., equal parts; Glycerin and lemon juice, equal parts; Boric acid and water, equal parts. The night attendants must be very careful and faithful in the care of the mouth during the night or the work of the previous day may be undone.

If the tongue and lips become dry and parched relief can be afforded by applying an oily, soothing lotion to them. In cleansing a patient's mouth, care should be taken not to tickle the back of throat; if the patient gags, stop at once to prevent causing nausea and vomiting. After a short time try again, urging the patient to relax and breathe through his mouth in panting fashion, which prevents gagging. If the mouth is too sore and tender for a toothbrush, soft linen or gauze moistened with one of the previously-named mouth washes and wrapped about the finger should be substituted, or cotton applicators used. In all procedures the hands of the attendant should be scrupulously clean. A patient's mouth should be cleansed fully 10 minutes before feeding time and not less than 10 minutes after taking food to lessen the danger of vomiting. In preparing the mouth swabs, cotton will adhere more readily to the applicators if the ends are dipped first in water.

The care of the mouth of a patient having false teeth is the same as that of other patients. The teeth, however, are removed for cleansing. At night they should be placed in a 2 per cent solution of boric acid.

While attending to the mouth and teeth it is well to see that the nostrils are kept clean. They may be cleaned by using a small applicator wrapped with cotton moistened with water or oil, after which a small amount of petrolatum should be applied on a fresh applicator.

A patient's face, neck, and ears should be kept clean by washing with warm water at least twice a day, his hair should be thoroughly combed, or combed and brushed, at least once a day and trimmed as often as necessary, and the nails of his fingers and toes kept clean and properly cut.

The **morning toilet** is the routine care given a patient before he has his breakfast. The object is to refresh and cleanse him after the night and to make him comfortable and ready for his breakfast. Bedpans and urinals should be passed and removed, the patient's face and hands washed, his teeth brushed, and his hair combed. The bed clothes should be straightened and changed if necessary, the draw sheets tightened, the pillows shaken up and rearranged, and the bedside table or locker made ready for the breakfast tray.

The **evening toilet** is given to all bed patients before 9:00 p. m. and should follow the last evening nourishment. It consists of the morning toilet routine plus an alcohol rub. Lights should be adjusted, extra ventilation regulated, extra coverings placed within reach, and fresh drinking water provided on the bedside locker.

Bathing a patient is most important in maintaining his cleanliness and baths given for that purpose are usually spoken of as *cleansing baths*. The cleansing bath may be a tub, shower, or sponge bath, and it is not advisable to give them immediately after eating as bathing has a tendency to bring the blood to the surface of the body and away from the digestive organs where it is needed. A cleansing tub or shower bath is generally given to patients who require little or no assistance in bathing, but may be given to others if ordered. A sponge or, as it is sometimes called, a bed bath, is usually given to patients confined to bed, or who cannot help themselves.

A cleansing bath is given for the purpose of removing the accumulation of skin secretions, dust, dirt, and other foreign matter in order to observe the patient, to aid in elimination by keeping the pores of the skin open, to produce a sedative effect, to prevent bed-sores by stimulating the circulation, to keep the body free from excess moisture and irritating accumulations, and for the general refreshing effect on the patient. At least one such bath daily is necessary for a very ill patient, and the usual time for giving it is in the morning. Special cases often require baths twice a day or oftener. Convalescent bed patients should be bathed at least three times a week. The cleansing bath is an essential and most important aid in the treatment, comfort, and recovery of a patient. The skin being an important excretory organ, should have its sweat glands kept in working order and their outlets free from obstructions. A factor in serious illness is the lessening of strain on the kidneys by free elimination through the pores of the skin. Cleansing baths make bedsores less likely to occur, prevent body odors by removing excess perspiration, sebaceous matter, etc., and, by removing causes of irritation, prevent pimples, skin rashes; and sores. Bathing also prevents the propagation of body vermin in that it enables them to be brought to notice and treated. By allowing frequent observation of the body, bathing brings to light any signs or abnormalities of disease or injury. By no means least among the benefits derived from the ordinary cleansing bath is the comforting, soothing effect produced upon the patient.

When a sponge, or bed bath, is given, expose the patient's body gradually and as little as possible during the procedure. Each part should be dried thoroughly immediately after washing, and especial care should be taken in washing and wiping the umbilicus, between the fingers and toes, between folds of flesh, and about the pubic region. While giving the bath work briskly, but smoothly and methodically, using long strokes with firm pressure and avoiding jerky dabs. Water should not be allowed to drip from the wash cloth and an excessive amount of soap should not be used. The attendant as a rule should stand at one side of the bed when giving a bed bath and the patient's hands and feet should, if possible, be immersed while bathing the arms and legs. To keep the bath water at an even temperature add hot water from time to time as necessary and for that purpose a pitcher of hot water should be on hand. All necessary clean linen and equipment should be at the bedside before starting the bath. *Unnecessarily exposing a patient when giving a bed bath is inexcusable and indicative of carelessness and faulty nursing technique.*

When giving a sponge or bed bath the temperature of the room should be not less than 72° F., the windows closed if the weather is cool, and the bed screened. In cold weather the clean bed linen and pajama suit should be placed on a warm radiator or wrapped around a hot-water bottle. The procedure then is to place a hot-water bottle at the patient's feet if necessary, loosen the bed clothes and replace the covers with a bath blanket over the upper edge of which a face towel is folded to protect the patient's face and chin from irritation. Remove one pillow, both if the patient does not object, and move the patient to the far side of the bed while a bath blanket is placed on the near side, onto which the patient is moved and which is also used to cover the opposite side of the bed. If the patient is very ill or helpless, the under blanket may be omitted and a bath towel used to protect the bed. After removing the pajamas wash the face, neck, and ears, washing well behind the ears, and in all of their grooves and crevices, and dry thoroughly. Next, place the bath towel under the nearest arm, making sure that the patient is far enough over to leave room for placing the tub under the hand which is immersed while bathing the arm. Wash well up into the axilla. Remove the

tub and holding the patient's wrist by a corner of the towel held in the left hand, with the opposite corner of the towel in the right hand, thoroughly dry the axilla, arm and hand. Move the patient to the near side of the bed and wash the other arm and hand in like manner. Next bathe the chest and abdomen, going well down on the sides and over the hips, protecting the exposed area with the bath towel and turning the bath blanket down to the hip line. Dry well, replace blanket, and turn the patient on his side, then, laying the bath towel over the bed close up to the patient's back, bathe the back with long, smooth strokes, being careful to wash well down over the hips and buttocks, well up into the hair line and over the shoulders. Thoroughly dry the back, rub with 50 per cent alcohol, and powder. Place the bath towel and foot tub on the foot of the bed and immerse one or both feet in the water, gathering the blanket between the legs to prevent exposure while washing the thighs and legs. Next wash the feet thoroughly, going firmly between the toes and across the bottom of the feet, to avoid tickling. Remove the tub, place the feet on the bath towel and dry well between the toes. If one corner of towel is held in one hand, the patient may be comfortably dried by a circular motion with the opposite corner of the towel in the other hand. Remember to take special care when washing the pubic region. When the patient is able he should do this himself, but never fail to attend to this portion of the bath when he is too ill or helpless to cleanse himself. The inner folds of the umbilicus may be thoroughly cleaned by using absorbent cotton swabs. Clean and cut the toe nails and finger nails as necessary, placing a towel under the hands and feet to receive the clippings and prevent their falling in the bed or on the deck. As bathing of each part of the body is completed it should be covered to prevent chilling. When the bath is finished remove the lower blanket and replace the under bed clothes in the routine manner. Put clean pajamas on the patient, and replace the upper bath blanket with fresh linen and the upper bed clothes. Cleanse the patient's mouth and teeth, comb and brush his hair. Remove the soiled linen from the ward, and remove the bath tray and put it in order. Leave the bed and surroundings in order, and the call bell within reach. Encourage the patient to rest and sleep after his bath.

The **care of the back** is important in safeguarding the patient in bed. At least twice a day, after the bath in the morning and as a part of the evening toilet, the backs of all strictly bed patients should be carefully examined for pressure spots, rubbed well with 50 per cent alcohol, and carefully powdered. All bony prominences require the same treatment. The object of this is to stimulate the circulation where, from pressure or inaction, the blood supply has been lessened; to toughen the skin and thus make it less sensitive to chafing and abrasions; to comfort the patient by soothing the nerves and stimulating the blood vessels, and thus lessen the danger of bedsores. For the comfort of the patient and for his own well-being, the attendant's hands should be kept in the best possible condition. They should be clean always, the nails short, clean, and free from rough edges. Hangnails and abrasions render an attendant susceptible to infection from a patient, and cause pain and smarting when alcohol is applied. Care should be taken not to pinch or pull the skin of a patient.

Bedsores or *pressure spots* are local ulcerating conditions usually accompanied by death of the tissues. These conditions frequently result from continuous pressure on one spot caused by the patient staying too long in one position; by interference with circulation from a too tight bandage or other appliance; and by the heat and excessive moisture of two skin surfaces which are allowed to be too close together without proper padding and powder. The

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conditions are often caused by the chafing of improperly applied splints, casts, and extension or suspension apparatus. The predisposing causes of bedsores and pressure spots are faulty nutrition, lowered vitality, irritating chemical agents, and body discharges as in septic cases; involuntary urination and defæcation; pimples or breaks in the skin; wrinkles and crumbs in the bed; excessive moisture of skin; damp, or soiled linen; and infrequent baths and improper bodily care.

The best treatment for bedsores is to prevent them. Their presence almost invariably denotes lack of care and watchfulness on the part of those responsible for the patient's welfare. To avoid and prevent bedsores, pressure must be relieved by the use of rubber or cotton rings, by frequent turning of the patient and changing his position when possible, by stimulating the circulation by frequent baths, and by massage and alcohol rubs especially about the points of pressure. The use of the air or water mattress keeps the body from becoming overheated and from suffering through undue pressure. In cases of severe fracture, as that of the pelvis or femur, it is necessary to watch continuously all points of pressure, to massage them often, and relieve pressure as much as possible even if for but a short period. The bed and body must be kept scrupulously clean and dry, and the bed free from crumbs and wrinkles. Pimples and abrasions must be attended to promptly and carefully. In cases of diarrhœa, or incontinence of urine, a pad should be kept constantly under the patient and it should be changed whenever soiled; parts should be cleansed, dried, and powdered after each evacuation of the bowel or bladder, and the pad, linen, and body kept dry and clean. A urinal, or rubber urinal, may be comfortably adjusted to receive the urine and protect the bed, which, to avoid accidents, should be watched closely and changed frequently.

The appearance of bedsores usually reflects very badly on the nursing care but sometimes even the best of nursing care cannot prevent them. This is particularly true in cases where patients are very thin and emaciated, have been bed-ridden for long periods of time, or have fractures in which splints or casts have been applied. Should bedsores develop only the areas surrounding them may be massaged with alcohol. The treatment of bedsores consists of keeping them clean, applying soothing and stimulating ointments, and covering them with protective dressings, or such other treatment as may be ordered by a medical officer.

In the prevention and treatment of bedsores hollow rubber rings of various shapes and sizes, commonly called air rings, when inflated to a sufficient degree, are often used to afford protection and support to various parts of the body, particularly to the pressure points. When filled too full with air they loose their resiliency, are hard and uncomfortable, and too greatly elevate the parts, while if inflated too little they lessen the protection from pressure, and are too flabby for support.

If air rings of the proper size are not available, rings of any desired size may be made of absorbent cotton wound about with gauze bandage. Care must be taken that these rings are made firm enough for support, but not of such a degree as to cause pressure. The hole in the ring should be large enough to surround the point of pressure, but not large enough to allow the point (for instance, the heel) to slip completely through, and so fail to relieve the pressure. The purpose of rings is to eliminate pressure on bony prominences, such as hips, elbows, ankles, and the coccyx. They are also used between the knees and under the heels of patients in bed for long periods, and of those who must remain in one position for a long time as in fracture cases. Rings must be inspected frequently and their position changed when necessary.

In the case of cotton rings a new one should replace the original one when it becomes flat, soiled, or hard.

Among the various measures tending to physically support a patient none, perhaps, is of more importance than the food and water he receives, and special care must be taken to see that they receive the proper kinds and quantities. From the average patient's point of view nothing probably makes more difference to him than his food and drink; what it is, how it is cooked, and how it is served, and to the convalescent patient with a returning appetite his three meals usually are the events of his day.

Illness tends to make a patient very fastidious and notional in regard to food. He may like some things to-day and to-morrow dislike them, or vice versa. The feeding of a patient must not be taken lightly because food is an important item in his treatment and return to health. Patients who are ill must have nourishment in sufficient quantity, and of the type and quality best suited to his condition and ability to assimilate, in order to have strength to resist the inroads of disease. Liquid nourishment should be varied; the time of serving arranged with due regard to food value. Merely refreshing drinks should be given between servings of the more nourishing ones. Helpless and very ill patients must be served without effort on their part, drinking tubes, special feeding cups, etc., being used to avoid raising the head, or causing any unnecessary strain. Foods which the patient dislikes but which have been ordered for him and are essential for his nourishment may often be disguised and given to him without his realizing it. For instance, an egg well beaten may be served in orange juice thoroughly iced, instead of in milk; milk in a cocoa or chocolate shake when the patient does not care for the milk alone; cream in ginger ale rather than as plain cream.

Prompt serving, sufficient quantity of food, tempting variety, and attractive arrangement of his food are strong factors in making a patient contented and happy. Cheerfully serving second helpings if desired by the patient, unless he is on a restricted diet, is helpful. In cases of restricted diet arrangement of the food so that it is as attractive as possible is an asset. An attendant not thoroughly familiar with the patients should make sure, by asking a patient his name, that the tray he serves is meant for that particular patient. Unnecessary waste may be eliminated and economy maintained by catering to the patient's desires to as reasonable a degree as is permitted by the hospital regulations and routine. This is accomplished by serving an attractive tray having the food well cooked and properly seasoned; by serving at regular intervals and on time; serving the food temptingly arranged on clean dishes on a clean tray and in moderate quantities, and serving hot foods hot, and cold foods cold. In serving food care should be taken that it is not "splashed" over the plate or left hanging over the edge to later drop in the tray cover. If the soup is slopped over onto the tray, or coffee or tea into a saucer, the tray should be returned to the diet kitchen and the tray cover changed. A sloppy, messy tray should never be served to any patient. When a patient is taking liquids only, care should be taken that they are served in a manner similar to other diets; the glass, cup, or bowl should be placed on a saucer or plate and served on a small tray, properly prepared with a clean cover and having the necessary silver, also sugar or salt as needed. All trays should be removed promptly after the patient has finished, but he should not be hurried in eating his food. The importance of thorough mastication should be emphasized. A note should be made on the clinical notes whether the patient's appetite is normal or not, and in cases so designated accurate record should be kept of all foods and liquids taken by the patient.

Before food is served in a ward there are a number of things that should be attended to in preparation of patients to receive their food. Necessary urinals and bedpans should be passed one-half hour to an hour before tray time and promptly removed after use so that none may be present during the meal hour and the ward free of unpleasant odors. Bed clothes should be smoothed and tightened and pillows arranged for the patient's comfort and support while eating. Unnecessary articles should be removed from the bedside locker or table to facilitate placing of the tray and if the sputum cup must remain it should be clean. A patient with persistent cough and frequent expectoration should be screened from the other patients, at least during meal time, and where possible should be in a room by himself or in one with similar cases. The patients' diet list should be posted daily and be correct and up to date in order that an attendant unfamiliar with the ward and the patients may serve to the right patient the right food, in the right amount, on the right tray, in the right way, and at the right time. Some one should have been previously designated to feed a patient who is unable to do so himself, and should be ready and waiting when the tray arrives, so that there may be no delay in serving. Delay in serving, with food in sight, irritates the patient, sometimes to the point of refusing to eat, and also results in cold food.

When, for various reasons, the digestive tract is not able to perform its normal function in the process of digestion, or because of unconsciousness, refusal to eat, or conditions where swallowing is impossible, food cannot be administered by mouth, it is necessary to resort to other methods of feeding. These methods are discussed in the chapter on Dietetics and Messing for the Sick.

The elimination of body discharges or waste products not only is a physical supportive measure but contributes greatly to the comfort of a patient. Body discharges are eliminated principally through the intestine, the urinary system, and the skin. In sickness as in health it is desirable that elimination through the intestine, known as defæcation, take place at regular times, especially as it tends to largely prevent the constipation which often results from the inactivity and disturbed routine accompanying illness. Some patients can be allowed toilet privileges but those who are not must be assisted by the attendant, and use of the bed-pan is required for many such cases. The *bed-pan* is a utensil devised to protect the patient from unnecessary exertion, exposure, and embarrassment; to prevent unnecessary discomfort to other patients in the ward; to prevent soiling of the bed linen and permeation of it with fæcal odors; to avoid chilling of the patient, and to assure cleanliness of the patient's body. The method of handling is to screen the patient during the use of the bedpan, warm the pan by running hot water over it, dry it and line with a couple of layers of toilet paper, then cover and carry it, together with a roll of toilet paper, to the bedside. If the patient is able, his head and shoulders may be raised slightly and supported, he should then flex his knees somewhat, while the attendant, supporting his back with his left hand, slips the pan under the buttocks with his right, and carefully adjusts it for the patient's comfort, and the proper protection of the bed. If necessary for the comfort of the patient and protection of the back in cases of extreme emaciation or tender skin, a pad of absorbent cotton should be placed on the back shelf of the pan. After the patient has used the pan cleanse him thoroughly, washing the region, if necessary, and drying it. In removing the pan, place one hand under the sacrum for support, raise the buttocks gently, and slip the pan out, taking special care to see that the skin of the back is not rubbed or injured in the procedure. Immediately cover the pan and take it from the ward. Rearrange the patient's

pajamas and the bed linen and air the room or ward. Before emptying the bedpan make an inspection of its contents for any abnormal appearance or unusual constituents. After emptying the pan clean it thoroughly with cold water, using a brush to remove all particles of fæces, then scald or boil it, dry and place in rack. Never take a soiled, improperly washed bedpan to the bedside. Guard against injury to the patient's back both in giving, and in removing the pan, also against soiling bed clothes and pajamas.

Body discharges are eliminated through the urinary system by means of urination, or the voiding of urine, and ordinarily occurs when the patient responds to the desire to urinate, or void. For bed patients the *urinal* usually is used, even though a bed-pan is also being used. For patients who are very weak, ill, or unable to help themselves it is necessary to adjust the urinal. To avoid accident it should be removed promptly, care being taken not to tip it and spill its contents in the bed, thereby causing added discomfort to the patient and unnecessary labor and loss of time by the attendant.

After a urinal has been used and the contents inspected it should be emptied at once and rinsed well first with cold water and then with hot water. Patients using a urinal should be screened to provide privacy and prevent embarrassment.

Proper covers for both bed-pans and urinals are provided, and for obvious reasons always should be used. At least once a day bed-pans and urinals should be boiled for 10 or 15 minutes in the bed-pan sterilizer, and if used for more than one patient they should be sterilized after each use. Those used for patients with infectious diseases should be properly marked, sterilized after use, and kept apart from others. Absolute cleanliness from the use of soap, water, and a scrubbing brush, and occasional thorough soaking in strong soap suds, is a far surer and more hygienic method of caring for bed-pans and urinals than is the use of strong disinfectants.

The elimination taking place through the skin, known as perspiration, usually "takes care of itself" provided the skin is properly cleansed and the pores kept open, and the temperature and humidity of a room properly regulated.

Rest, sleep, and exercise are the last of the physical supportive measures to be considered. Plenty of rest and sleep are necessary for the majority of all patients and many things may be done by an attendant to help the patient in obtaining them. By *rest* is meant the complete relaxation of the patient in which his body is limp, without tension, and is supported entirely by the bed or chair without any physical effort of his own. Mental relaxation follows complete physical relaxation and the patient becomes calm and peaceful, at which time the greatest benefit from his treatment is derived and healing processes work best. To obtain such relaxation a bed must be comfortable, with pillows and linen arranged with a view to provide all possible comfort, and chairs, when used, should be of a design suitable for relaxation and large enough to permit arranging pillows and blankets to meet the patient's wishes. To change a patient's position relieves pressure on bony prominences and muscle strain, and improves circulation, all of which are conducive of comfort and relaxation is easier. It may be necessary to make such changes every 2 or 3 hours and the use of pillows, sandbags, etc., may be required to support and maintain the patient in the position desired and avoid strain and fatigue. It is desirable that a patient's shoulders should not sag forward, that his arms should not drag on the shoulder or lie heavily against the body, that the abdomen be flat, and that the chest allow plenty of room for expansion of the lungs.

To further the restful relaxation of a patient efforts should be made to relieve any physical cause of restlessness and to remove any cause for worry, as both restlessness and worry are conditions inimical to the well-being of anyone, sick or well.

Sleep is considered to be a condition in which all the organs of the body generally relax, rest, and recuperate. During sleep all voluntary activity both of body and mind ceases and repair processes proceed unhindered. Sleep is an important factor in the recovery of the sick or injured and is especially beneficial when it is unbroken and dreamless. Great care must be exercised to avoid disturbing or awakening a patient, as it is often difficult for them to return to sleep. Turning on lights, bumping the bed or touching the patient, whispering, and all noise should be avoided as much as possible. Sleep often follows complete relaxation, even in the daytime, and the evening toilet generally induces sleep.

Exercise, in judicious amounts and properly guided, plays a part in the recovery of patients that must be considered. It is particularly worth while for patients who are well on the way to recovery. Even with bed patients exercise is possible and desirable if it does not interfere with treatment. The arms, legs, and trunk can be moved in ways that will stimulate circulation, encourage elimination, and help to keep up a patient's strength. As the patient's condition improves the kind of exercise he takes changes and the amount increases until it is no longer necessary to guide or observe him.

Administration of medicines and of therapeutic treatments.

As has been explained in Materia Medica the substances used in the treatment of disease generally are spoken of as medicines. In addition to the internal and local administration of medicines, agents other than medicines, or drugs as they are usually called, are employed in the treatment of disease for their therapeutic effects.

The administration of medicines and therapeutic treatments is a most important part of nursing and is a responsibility fraught with great dangers. Whoever is assigned to the task must thoroughly realize that responsibility and be absolutely honest and trustworthy.

Those responsible for the administration of medicines should be familiar with the normal physiological action of drugs commonly used so that they may be able to quickly recognize any unusual effects following their administration, as some individuals have an idiosyncrasy for certain drugs. They should know: (*a*) The average dose and the minimum and maximum dose of ordinary drugs, especially of powerful or poisonous ones; (*b*) The antidotes of poisons and the first-aid treatment following their introduction, which makes possible the speedy assembling of required means of treatment and the prompt administration of the remedy; (*c*) The ordinary cumulative drugs, the usual length of time they are taken continuously, and the symptoms indicating systemic accumulation; (*d*) The ordinary symptoms manifested by a drug addict; (*e*) The importance of having a definite place for each drug, so that no time will be lost in locating it; and (*f*) The symbols and abbreviations used in writing prescriptions and orders.

It is very helpful in preventing mistakes if those who give medicines learn an old adage called the "Five Rights" which is: "Give *the right dose* of *the right medicine* to *the right patient* in *the right way* at *the right time.*"

The following are important points to be always remembered by those giving medicines:

1. Be accurate. By this is meant that one should: (*a*) Think of nothing else while giving medications; (*b*) Read the label carefully three times before

giving any medicine—before taking the bottle from the shelf, before and after pouring the medicine, and before returning the bottle to the shelf; (*c*) Be sure that the order is clearly understood; (*d*) Never pour medicines in an obscure light; (*e*) Give drops when drops are ordered, minims when minims are ordered; (*f*) Never give medicine from an unmarked bottle or an illegibly labeled container, or leave a dose standing unmarked; (*g*) Pour the medicines which are to be given and give the medicines which are poured; (*h*) Never allow one patient to carry medicine to another; and (*i*) Never record giving a medicine before it is given.

2. Never combine medicines or give different medicines at the same time without an order from the medical officer.

3. Never give a pill or powder to a delirious, unconscious, or very ill patient but dissolve them in a little water and drop far back on the tongue, or give as otherwise directed.

4. Acids and medicines containing iron should first be well diluted to prevent irritation of the mucous membranes and then given through a glass tube or a straw to protect the teeth.

5. Give syrupy cough medicines undiluted because dilution lessens their soothing effect.

6. Make a disagreeable medicine as palatable as possible. Castor oil may be given in various combinations to disguise its taste; for example, rinse a glass with orange or lemon juice, leaving an ounce in the bottom of the glass, pour in the castor oil, then more orange juice; add a piece of ice to chill the mixture and instruct the patient to hold his nostrils together and take dose far back in the throat. A small amount of baking soda stirred into this mixture makes it more easy to take by some patients.

7. Saline cathartics given to lessen œdema should be given in as small a quantity of water as is possible, but when given as a purgative should be given with plenty of water.

8. Liquid medicines containing a precipitate or prepared by a combination of drugs should be shaken well before being poured. The medicine list should be compared daily with the doctor's order book and all necessary changes made. This list should be absolutely accurate and always up to date. If a verbal order or order by telephone is received, repeat it before leaving the phone, record it as soon as possible, and have the medical officer sign it on his first visit to the ward.

The proper **care of the medicine locker**, which includes the cleanliness and arrangement of the contents, is important. The locker must be cleaned at regular intervals and in cleaning it is best to start at the top and work down. Only a few bottles should be removed at a time so that they may be quickly replaced if the locker has to be locked before its cleaning is finished. Each bottle should be wiped off before returning it to the shelf, paying particular attention to the neck and rim, and being careful not to deface the label. Each bottle should be properly stoppered as many drugs are combined with or dissolved in volatile substances and will become weaker or stronger if allowed to remain uncorked.

Poisons and drugs for external use should be kept on a separate shelf or in a separate compartment of the medicine locker. Opiates, habit-forming drugs, and alcoholic stimulants should not ordinarily be kept in the ward medicine locker, but in a special place reserved for them. A careful record of amounts received and amounts administered must be kept, and when narcotics are given they should be entered immediately on the patient's chart, in the ward record book, and in the narcotic book. Drugs used for eye treatments should

be arranged separately from those used by mouth or externally. Never put drugs used externally or for disinfecting purposes in a medicine glass. Medicines and preparations injured by heat, such as serums, vaccines, insulin, cod-liver oil, and suppositories, should be kept in the ice box or some compartment in the refrigerator reserved for their storage. Medicines injured by the light should be kept in dark bottles, enclosed in outer cover, or kept in a dark place. Emergency stimulants such as epinephrine (adrenalin chloride), camphorated oil, amyl nitrite, and aromatic spirits of ammonia should be in a prominent, easily accessible place in the medicine locker. The location of these emergency stimulants should be the same always so that no time will be lost in obtaining them when needed.

The person responsible for medications should make a note when supplies of drugs need replenishing and should plan always to have on hand a quantity sufficient for 24 hours and for over a week-end. One should never wait until the supply is completely exhausted before ordering more. Drugs to be given in small doses should be ordered in small amounts, and when a patient having a special prescription is sent to duty or otherwise discharged the container should be returned to the pharmacy unless other patients are receiving the same medicine.

Bottles of uniform shape and size should be provided for the medicine locker. Rough blue bottles with rough glass stoppers are required to be used in the Navy as poison containers. Dark brown bottles are provided for drugs injured by light. Glass stoppers should be used in all bottles containing drugs which disintegrate cork stoppers. Bottle **labels** should be kept clean and should only be changed and replaced in the dispensary. All bottles containing poisons should be marked with the regulation red "Poison label." The size of the label may vary with the size of the bottle, but must always be large enough for easy reading. All medicines containing a precipitate and those formed by a combination of drugs should be in bottles labeled "Shake well before using." Medicines should be poured from the side of the bottle opposite the label, and the neck and rim wiped off immediately after pouring.

The "medicine tray" should contain a pitcher for cold or iced water, medicine glasses, glass mixing rod, spoon, pieces of gauze, and medicine tickets in their proper receptacle. Each patient should have his own drinking glass and, where necessary, his own drinking tube. Medicine glasses, pipettes, measuring glasses, drinking tubes, etc., must be washed thoroughly after use and boiled or disinfected when necessary. A medicine list should be prepared and hung or posted in or close beside the medicine locker, with each name, medication, dose, time due, and location of patient written or printed plainly upon it. "Medicine Tickets" made of squares or oblongs of cardboard on which are inscribed the patient's name, the medicine, dose, and time due are sometimes used as a means of insurance that the right patient gets the right dose of the right medicine at the right time. These tickets may cover the tops of medicine glasses or may be attached to them. When not in use they are kept in trays which are usually divided into compartments representing the different hours. When ready to prepare the medicines for administration, all tickets designating the same hour should be selected and all those specifying the same medicine grouped together.

To prevent accidents and deliberate meddling it is necessary to **keep the medicine locker locked** at all times except when access to its contents is necessary. The keys to the medicine locker must be carried by the person in charge of a ward or in their absence by the next junior. The locker should be opened at weekly inspection only when a request is made by the command-

ing officer, and should be locked immediately following his inspection, in his presence.

In giving **medication by mouth**, the following procedure should be strictly adhered to: Take the medicine glass in the left hand, read the label on the medicine bottle, and, taking the bottle from the shelf, shake its contents. Take the cork between the third and fourth fingers of the left hand and remove it. Read the label again. Raise the glass until the mark gauging the amount to be given is on a level with the eyes and pour into it the required amount. If more than one patient is to receive the same medicine, pour the required number of doses before wiping the bottle, recorking it and replacing it in cabinet. Read the label again as bottle is returned to shelf to make sure that correct medicine has been poured. Add iced water or small portions of ice to the medicine and place the medicine tickets on the glasses. Before giving the medicine to the patient read again the name on the medicine card so that there may be absolutely no chance for a mistake.

Medication by inhalation is given in the form of *moist inhalations* when the local effect of the medicine in relieving inflammation is desired, as in laryngitis, bronchitis, etc., or in the form of *dry* or *gaseous inhalations* when the systemic effect of the medicine is desired, as amyl nitrite, oxygen, ether, chloroform, etc. In moist inhalations the medicine used is contained in the steam vapor arising from boiling water and may be given with an apparatus so arranged that the exit for the medicated vapors is in close proximity to the patient's nose and mouth. The steam atomizer is a special apparatus for this purpose. In the absence of the steam atomizer, drugs to be given by inhalation may be put in a pitcher of boiling water, covered with a heavy paper cone or bag with an opening at the top of sufficient size to permit free escape of the medicated vapors but small enough to keep steam concentrated in volume about the nose and mouth which are placed close to the opening. A heavy bath towel thrown over the pitcher and patient's head make an excellent substitute for the atomizer. For continuous inhalations of steam a croup tent may be constructed. One of the most common medicines given by dry inhalation is oxygen, a colorless and odorless gas. It is confined under considerable pressure in large metal containers. The simplest method of giving oxygen is by means of an apparatus which provides for its passage through water before being inhaled. The force of its flow is regulated by a wrench or key attached to the tank and is measured by a gauge with dial. In the absence of the gauge the activity of the bubbles in the water gives a very good idea of amount of pressure. The rate of flow should be regulated before holding funnel over patient's nose and mouth. The stream should be slow and steady and the funnel not close enough to patient to prevent free escape of exhalations before the patient inhales the oxygen. There are special and more complicated methods of administering oxygen. As oxygen is expensive the valve on the tank must be securely closed after use to prevent waste and loss. Tanks emptied should be tagged at once so that they may be replaced with full ones and an adequate amount kept on hand for emergencies.

Oxygen tents are of different types and the person responsible for the care of a patient in the tent must be sure to know how to use the apparatus. The medical officer's orders as to temperature, humidity, and rate of oxygen flow must be strictly followed. Never run an oxygen tent until properly instructed by an authorized person.

Subcutaneous medication is the hypodermic injection of drugs or their easily soluble preparations into the subcutaneous tissue of the body. This form of administering drugs is adopted when prompt action is required; when medicine

cannot be taken by mouth; when a drug is undesirably acted upon by the gastric juices; and when the effect of the drug is desired in the area of injection, for instance, a local anæsthetic. When using this method it is important to remember the following: To avoid injury to nerves, not to make injection along the course of a blood vessel (the outer surfaces of the arms and legs are most commonly chosen as sites for subcutaneous injection), and to prevent infection by aseptic technique, by using a smooth, sharp needle, and by careful handling of the flesh to avoid bruising, i e., hold the flesh firmly; do not pinch. Guard against breaking off the needle in the body surface by explaining the procedure to the patient and reassuring him before starting, by using a perfect needle, and by having adequate assistance when giving to a delirious or highly nervous patient. A hypodermic injection should be given as quickly as safety will allow (a quick, sure stab is less likely to bend or break the needle than a slow push, and is easier for the patient, being less painful and more quickly over). Immediately report any mishap. The "hypodermic tray" should contain the following articles: Alcohol lamp filled with alcohol, 95 per cent; matches; a spoon with handle so bent that the bowl rests evenly when it is placed on the table; alcohol, 70 per cent; sterile cotton or gauze pledgets; sterile forceps in jar of 5 per cent lysol; a flask of sterile water; the drug or tablet necessary for the injection; a hypodermic syringe and needles; and a receptacle for waste. The procedure in preparation of the syringe and needle should be as follows: Scrub the hands thoroughly, inspect syringe and needles to be sure the syringe does not leak and that the needle is neither bent, blunt, rusty, nor plugged. Replace the wire in the inspected needle, place the needle in the spoon, cover it with water, and boil over the flame of the lamp for one minute. Take a sterile pledget from the jar with forceps and put it on glass. Disinfect the inside of the syringe by drawing it full of alcohol and expelling same five or six times. Moisten sterile pledget with alcohol; remove needle from spoon and wire from needle and place the needle on the sterile pledget. Rinse the syringe by drawing up sterile water from spoon and expelling it; then draw into the syringe sufficient sterile water to dissolve the tablet, discarding the remainder left in spoon. Dissolve the tablet in the spoon with the water from syringe, making sure that every particle is dissolved. A tablet not readily dissolved, as caffeine sodium benzoate, makes it necessary to hold the spoon over flame, until the tablet is dissolved. In such a case a larger quantity of water is needed, 20 to 30 minims instead of 15 to 20 minims. When the tablet is thoroughly dissolved, draw all solution into the syringe; fit the needle securely onto the syringe; expel air from syringe and needle by holding it upright and exerting slight pressure on the piston until a few drops of solution flow through the needle; hold syringe on a level so that the piston will not fall back, and keep the needle covered with alcohol pledget.

The site chosen for a hypodermic injection should be thoroughly cleansed with alcohol just before giving the injection. Then, holding the syringe firmly between the thumb and first two fingers of the right hand take up a fold of flesh with the other hand, holding it so that a firm, smooth surface is exposed. Into this insert the needle with a quick, firm pressure. Do not touch the piston while inserting the needle. Withdraw the needle slightly, readjust the fingers, and inject the solution. Do not move the needle while doing this. Withdraw the needle quickly after the solution has been injected, hold an alcohol sponge closely over the point of injection for an instant, then gently massage the distended tissue until absorption is well established. Rinse out the needle and syringe first with water and then with alcohol. Inserting, drawing out, and

wiping the "hypo" wire, repeating as often as necessary, is a sure way to dry out the needle; and this is very essential to prevent a small rust spot clogging the bore or blunting the end of the needle. Waste ether is excellent for drying out the bore of a needle.

When giving serums or insulin, which come in special rubber-stoppered bottles, the head and neck of the bottle should first be wiped off with iodine and alcohol. Having a sterile hypodermic syringe and needle ready, with the piston partly withdrawn, insert the needle through the rubber covering, force a small amount of air into the container by pushing in the piston, and then withdraw the required amount of solution.

Intramuscular medication is the injection of drugs or their easily soluble preparations into the skeletal muscles. As absorption takes place more readily in the deeper tissues, intramuscular injections are given when the drugs to be used are not easily absorbed, when a drug is especially irritating to the tissues just below the skin, or when a large quantity of solution is to be introduced. The gluteal, lumbar, and deltoid muscles are sites frequently chosen for these injections. The equipment for this method is the same as for the hypodermic tray plus iodine, 5 per cent, and a larger syringe and needle. In preparing for an intramuscular injection, paint the site with iodine, 5 per cent. Boil the needles, and boil the syringe, or immerse it in 70 per cent alcohol for half an hour. (An all-glass syringe may be boiled, but one which has metal attachments cemented to the glass cylinder is ruined by boiling.) The skin where medication is to be given must be held tense by pressing in opposite directions with the thumb and fingers of left hand. Insert the needle almost perpendicularly, quickly, and steadily into the muscle. Subsequent procedure is the same as for subcutaneous injection, except that the somewhat larger point of injection is sealed with collodion.

Medication by intravenous injection (sometimes called intravascular injection), is the introduction of a solution of a drug or an easily soluble preparation of a drug directly into a vein. A vein at or near the bend of the elbow is usually selected for intravenous injection, the median basilic or median cephalic being most commonly used. Occasionally the vein chosen will be found deeply embedded in the surrounding tissues and it is then necessary to cut through the skin and dissect out the vein. If such dissection is required the site should be thoroughly cleansed and sterilized and only sterile instruments used.

Intravenous injections are always given by or under the direct supervision of a medical officer aided by trained assistants. Two of the drugs with the intravenous injection of which a hospital corpsman will most frequently come in contact are arsphenamine and neo-arsphenamine, the solutions of which are usually prepared by trained technicians under the supervision of a medical officer. On the day when a patient is to receive intravenous medication no food should be given to him in the morning.

It should be remembered the transfusion of blood is by intravenous injection.

Hypodermoclysis (sometimes called hypodermatoclysis) is the introduction of large quantities of fluids into the subcutaneous tissues when rapid absorption is desired. An increased flow from the kidneys usually can be noted within 15 minutes. It is used to replace body fluids that have been lost through excessive purging, as in cholera, or through hæmorrhage, and to supply fluid to tissues which are suffering from a lack of fluid and the body with liquid when liquid cannot be taken into the stomach because of vomiting, gastric ulcer, or surgical operation. Its use in the treatment of burns, intestinal obstruction, and surgical shock is frequently of great value.

The solution most frequently given by hypodermoclysis is physiological salt solution, and occasionally dextrose, with or without saline solution, is given in this way. The temperature of the solution when given should be about 100° F. and the amount given at one time usually varies from 500 cc to 1,000 cc.

The site chosen for hypodermoclysis in most cases is the loose flesh under the breasts, the shoulder blades, or in the abdomen, and should be prepared with the same aseptic care and precaution as if for a surgical operation.

Excessive accumulation of fluid in the tissues should be avoided by regulation of the rate of flow and by gentle massage in the region of the introduction. Absorption may be facilitated and swelling and pain largely prevented by the use of hot fomentations over the area.

When a large amount of solution is to be given, when absorption is slow, or it is desired not to have too much solution introduced in one place, 2 needles and 2 lengths of tubing connected by a glass Y-tube to the single length of tubing attached to the irrigator jar may be used, each needle being inserted in a separate site.

Proctoclysis, also known as Murphy drip and rectal seepage, is the slow, continuous, drop-by-drop instillation of a liquid into the rectum for the purpose of being absorbed. The liquid so instilled may be physiological salt solution, 5 per cent dextrose solution, 2 per cent sodium bicarbonate solution, or plain sterile or distilled water. When saline solution is used in proctoclysis it provides fluid to replace body fluids lost through hæmorrhage, profuse perspiration, diarrhœa, excessive vomiting, or lack of fluid intake and acts as a stimulant in cases of shock. Solution of dextrose provides a small amount of nourishment; solution of sodium bicarbonate helps to prevent and aids in the treatment of acidosis. The use of water dilutes toxins, aids in the elimination of infectious material, helps flush the kidneys, and supplies the body with fluids, being especially valuable in relieving the excessive thirst accompanying many cases of peritonitis.

In giving proctoclysis a special apparatus so arranged that the inflow of fluid may be regulated to any required number of drops per minute should be used. Regulation of the flow may be accomplished by use of the Murphy bulb and a screw clamp or guage or a practical substitute therefor, or by elevating the irrigating jar to the height where the proper flow is obtained by gravity. The latter method is especially useful when the special apparatus is not obtainable.

The proper temperature for the fluid in proctoclysis is 110° F., and in order to maintain that temperature it is necessary to have some means of heating the fluid just before it enters the rectum. A metal hot-water bottle with a hollow channel for the tubing running diagonally through its center has been devised for this purpose, but it is expensive and not ordinarily available. A satisfactory substitute is an ordinary rubber hot-water bottle which is filled only to the point that will allow it to be folded over on itself with the tubing passing between the folds. As either hot-water bottle must be placed in the bed near the patient it must be completely and adequately covered to avoid burning the patient and there must be a frequent inspection made for the same reason.

For proctoclysis it is necessary that the following equipment should always be in readiness: Irrigating jar or can with rubber tubing, gauge, Murphy-drip bulb (if available) for observation of drops, glass Y-tube connected with 2 lengths of rubber tubing (one for inflow of solution, the other for the escape of gas and back flow of solution), a single length of tubing connected with a

catheter by a glass connecting tube; a standard for the irrigating can, or jar; a solution thermometer; a large cotton pad to be placed under the buttocks of the patient for protection of the bed; a towel to cover the irrigating can; a lubricant; a pitcher of solution, properly prepared and of the proper temperature; a kidney basin; and some appliance for maintaining the proper temperature of the solution. (*See* under Enemata for the preparation of the patient and the bed and remember that a cleansing enema should first be given).

When giving proctoclysis be sure that the tubing is of the proper length, as too long tubing allows sagging and accumulation of fluid while too short causes tension of the tubing and danger of its slipping out of the rectum. Regulate the drops to the required rate per minute, place the heating appliance in the bed in such a position and so protected that it cannot burn the patient and the solution will not cool too quickly. Have sufficient tubing extending beyond the heating appliance to allow for insertion in the rectum without tension. The attendant should remain with the patient long enough to be certain that the catheter is securely placed and that no pressure from gas, fæces, or constriction is forcing it out; also to make sure that there are no leaking connections and no back flow from the rectum into the bed. The amount of solution in the can when the flow is started should be noted and recorded, and the time. Cover the irrigating can with a towel, and inspect the contents of the can from time to time and replenish as necessary, making a record each time of the amount absorbed and of any loss. Inspection of all apparatus must be frequently made to avoid wetting the patient and bed, or burning the patient. If fluid leaks out around the tube at the rectum, inspect for obstruction in tube or rectum or to see if the tube has partially slipped out; when absorption is not taking care of the fluid fast enough, reduce the number of drops per minute or discontinue the proctoclysis for a time, notifying the medical officer of the fact. Sometimes proctoclysis is given at intervals instead of continuously. Special watchfulness must be maintained to prevent the bed becoming wet and the patient chilled and to prevent the binder and dressings becoming contaminated.

The **administration of therapeutic treatments** is concerned with the use of agents other than medicines to produce therapeutic effects. The use of such agents is largely external and in their application there is required considerable skill, manual dexterity, and physical ability on the part of those giving such treatments.

When therapeutic treatments are applied externally their action naturally takes place through the skin and the effects produced may be local or remote. The **application of heat and cold** to the body in the treatment of disease constitutes one of the most important procedures in general nursing practice, and has for its principal objectives: 1. A change in blood distribution and the amount of blood present in any area or areas; and 2. A local or general change in body temperature. When *heat* is applied to the body the circulation is quickened, the skin becomes flushed and warm as its blood vessels are dilated, perspiration is increased, the temperature is raised, and the blood supply to the head and internal tissues is decreased. When *cold* is applied to the body the circulation is slowed, the skin becomes pale and cool as its blood vessels are constricted, perspiration is decreased, the temperature is lowered, and the blood supply to the head and internal tissues is increased; later, when reaction occurs from the effects of cold, the blood supply to the head and internal tissues becomes normal and the other conditions mentioned change to the opposite.

Hot packs and hot baths are given principally to induce perspiration and to relieve muscular tension.

The articles necessary for giving *hot packs* are: An ice cap, four blankets, one towel, a foot tub lined with a rubber sheet in which to carry blankets wrung out of very hot water, five hot-water bags, pitchers of hot and cool water, a glass and drinking tube, and a large rubber sheet.

Soak two blankets in water at 150° F., leaving one corner of the upper and lower edge of each blanket out of the water (these corners should be diagonally opposite each other, as the blanket will then, when stretched, be somewhat on the bias); wring each blanket separately (two attendants are required, each taking a dry corner and twisting in opposite directions until the blanket has been wrung dry.) It then should be placed in the foot tub lined with a rubber sheet covering hot-water bags, and the process repeated with the second blanket; carry the blankets to the bedside while the rubber sheet is still folded over them; pass two dry blankets with rubber sheet between under the patient; remove the pajama suit; wrap the patient in the dry blanket upon which he is lying; and turn the upper bedclothes over the foot of the bed. Place one hot blanket under the patient and one over him; fold the rubber sheet over the wet blankets; pull up the bedclothes, placing a towel around the patient's neck; apply an ice cap to the head and hot-water bags to the hips, arms, and feet. Watch the patient's pulse and encourage him to drink freely, unless directed to the contrary. The usual duration of this pack is 20 minutes.

During and after removing a hot pack take the pulse at the temporal artery frequently; give plenty of fluids while the patient is in the pack; watch for collapse, in which case discontinue the pack and apply external heat; remove the wet blankets under cover of a dry one, thus avoiding exposure; wrap the patient in a dry blanket and leave an ice cap applied to the head and a hot-water bag to feet. Draw up the bedclothes and let the patient remain between blankets for one hour, at the expiration of which time dry the patient and give him an alcohol rub.

Two commonly-used methods for applying heat are the *foot* and *sitz baths.*

Foot baths are used for the relief of congestion either in the feet or in some other part of the body, as the throat, abdomen, or chest. Sometimes mustard is added in the proportion of two tablespoonfuls to the gallon of water.

To give a foot bath in bed the articles required are a foot tub full of water at 108° to 112° F., a large blanket, a small towel, and a pitcher containing water at 130° F.

Loosen the upper bedcovers at the foot of the bed and double them back to expose the feet and legs to the knees; gently lift the legs and arrange a rubber sheet, covered with a bath towel, on the bed under the feet; place the foot tub on the bed alongside of the feet and place a folded hand towel over the edge of the foot tub upon which the legs will rest when in the tub. Next put the arm nearest the foot of the bed across the tub and place the other arm, the hand of which supports the heels, under the patient's legs; raise the feet from the bed and at the same time draw the tub into position; place the patient's feet gradually into the tub, lowering and lifting them into and out of the water several times until he becomes accustomed to the temperature, keeping the free arm across the tub during this procedure. A folded blanket then may be wrapped around the tub and the bedclothes drawn down. The feet usually are left in the water for 20 or 30 minutes, and the water maintained at the required temperature by adding water from the pitcher. During this process place the hand between the stream of water and the patient's feet to guard against injury. In removing the feet put

one arm and hand under the patient's legs and heels; lift the feet from the tub; hold them above it for a few seconds in order that the excess water may drain off; place them on a bath towel; remove the tub from the bed; and dry the feet and legs thoroughly. Gently remove the rubber sheet and towel and replace the bedcovers.

In the **sitz bath** the thighs and trunk up to the waistline only are immersed; the temperature of the water is 110° to 112° F.; and the duration is from 5 to 10 minutes. It is used principally for the relief of local inflammation in the pelvic region.

Cold is applied principally for the purpose of: 1. Stimulation of the vital processes, circulation, respiration, etc.; 2. Relief of congestion; 3. Stimulation or quieting of the nervous system; and 4. Reduction of temperature.

The primary effect of cold is the contraction of the superficial blood vessels and drives the blood from the surface to the interior of the body.

The following rules should be observed in the administration of cold baths: A cold compress or ice cap should be applied to the head to prevent an increased flow of blood to that part of the body; a hot-water bag should be placed at the feet, as this tends to prevent chill or rigor, conditions which are evidence of muscular contraction and a too decided difference between the temperature of the central and the peripheral portions of the body. Continuous light friction is given for the same reason. Stimulants should be administered 15 or 20 minutes before the bath to prevent chilling and to help counteract any undesirable effect from immersion; hot drinks should be given after the bath, and blankets should be left on until reaction takes place.

Baths to reduce high temperature usually are given every three or four hours while the temperature is 103° F. or over. The temperatures of cold baths vary from 65° to 95° F., and the duration also varies (10 to 20 minutes being the average). The temperature, pulse, and respiration always should be taken one hour after the bath and charted with dotted line to indicate the drop or rise.

When giving a **cold pack** protect the bed with a rubber sheet; wrap a wet sheet around the patient in such manner that no two surfaces of skin come together; apply a binder to the loins; keep the sheet wet by squeezing water of the required temperature over it; rub the surface of the sheet briskly; apply an ice cap to the patient's head and a hot-water bag to his feet. The duration of the pack should be 15 minutes.

In giving a cold pack *when the patient is not to be turned*, the following apparatus and materials are essential: A large basin or foot tub containing water at the temperature prescribed (usually 60° to 70° F.); three bath towels; several cotton or linen towels, the number depending upon their size (usually seven or eight); a bath thermometer; a basin containing a few small pieces of ice; an ice cap or compress; a hot-water bag; and a binder for the loins.

Remove all top covers except the sheet; pass the binder around the pelvis; protect the bed by placing a bath towel on either side of the patient and one over the legs; wring the towels fairly dry and place them around the arms and legs and over the chest and abdomen; remove the top sheet; have an extra towel in the water with which to start changing those on the body, and change them in turn at the rate of one every minute, rubbing the towels covering the body between changes. Dry the body by rubbing with a dry towel; cover with a blanket; apply a hot-water bag to the feet; draw up the bedclothes and administer a hot drink of either broth or beef tea.

In giving either a hot or cold pack be careful that no two skin surfaces are permitted to come together; watch for collapse during the process; protect the bed; avoid pressure upon the abdomen; avoid too much turning of a very

ill patient; heat should be applied after a bath; screen the bed; prevent drafts; have the room warm before giving the bath.

When the giving of a cold pack, a cold bath, or a cold sponge is inadvisable, an **alcohol sponge** is often employed to obtain the desired results. Less solution is used in giving an alcohol sponge, for alcohol evaporates more rapidly than water, thus giving greater stimulation to the nerve endings, and causing more rapid cooling of the skin. An alcohol sponge is given when it is unwise or impossible to move the patient too much; when quick results with less danger of violent reaction are desired; when the shock of the ordinary cold-water sponge would be too great; and when for any other reason other baths are contraindicated. One quart of 50 per cent alcohol is necessary.

Before starting to sponge take and record the patient's temperature, pulse, and respiration, noting particularly the character of the pulse and respiration. Then bring equipment to the bedside; replace the top covers with a bath blanket and fold the covers to the foot of the bed. Remove the patient's pajamas, place an ice-cap on his head and a hot-water bottle at his feet. Place a rubber sheet covered with a bath towel under each arm, slipping them well under the shoulder and axilla, down along the side of the trunk and well under the hips. Similar protection should be placed under the legs and thighs. Spread the patient's legs well apart, place his arms away from his sides and arrange a loin cloth or towel over the pubic region. Give the patient a quick, light friction rub over the body. The alcohol solution should be kept at the desired temperature by adding small lumps of ice as necessary and in it should be placed 6 compresses. Compresses, well wrung out, should be placed over the abdomen and, rolled or folded, in each axilla, and should be changed every 3 minutes. Fold the bath blanket to the foot of the bed using a bath towel for any necessary protection of the body; exposure of the body to the air assists in the radiation of heat, the evaporation of moisture, and the consequent cooling of the body surface. With long, light strokes sponge the nearest arm and leg, allowing three minutes for each; next sponge the chest, then the opposite arm and leg. If permissible to turn the patient sponge his back, buttocks, and along the back of his legs, using long, smooth strokes, otherwise raise one side and then the other enough to allow sponging underneath as far as possible to reach. In the same manner raise each leg and sponge the under surface as freely as possible. Apply friction if patient shivers, and watch constantly for unfavorable reaction, frequently feeling the pulse. Dry, if necessary, with light strokes of the towel. Draw up bath blanket (or sheet) and remove compresses and loin cloth. Finish procedure and make patient comfortable according to routine for other baths. Take temperature one-half hour to one hour following the sponge, and keep constant watch of pulse and respiration during and for some time following the sponging.

For some conditions **medicated baths** may be ordered, the temperature of the bath, the quantity of the medicament and the length of time the bath is to be taken also being specified.

For medicated baths the trunk and extremities should be covered by the bath water which requires the tub to be between half and three-quarters full; an ordinary-sized bathtub when half full contains about 25 gallons of water.

In medicated baths the patient lies quietly in the bath for 10 to 20 minutes and then is removed and enveloped in a warm sheet and dried gently by patting over the sheet. These baths are given largely for their soothing effect upon the irritated skin; rubbing will counteract the benefit of the bath and should not be practiced.

Of the medicated baths the *bran, starch, bicarbonate of soda,* and *sulfur baths* are used in the treatment of skin diseases, and *mustard, Nauheim,* and *salt baths* are used to produce counterirritation, improve the cutaneous circulation, and thereby relieve congestion of the viscera and for other abnormal conditions.

For the **bran bath** 1½ pounds of bran contained in a thin cloth bag is boiled in a basin for 20 minutes, the fluid drained off and added to the bath water, which should be at a temperature of about 95° F.

The **bicarbonate of soda** or **alkaline bath** is generally used to allay itching of the skin. It is prepared by dissolving in the bath 8 ounces of bicarbonate of soda to each gallon of water used. When tested with red litmus paper it should give a strongly alkaline reaction. If the water has a slippery feeling it is sufficiently alkaline.

In the **starch bath** one-half pound of starch is first mixed with sufficient cold water to cover it and enough boiling water is slowly added so as to make a paste of about the consistency of thick cream, which is then poured into the bath water and thoroughly mixed with the hands.

For the **sulfur bath** ½ to 2 ounces of sulfurated potash to each 15 gallons of water is dissolved in a small quantity of hot water and added to the bath water, which should be at a temperature between 85° and 95° F.

Substances which produce more or less local vascular excitement when applied to the skin are termed *irritants* and when these or other substances are employed to excite a reflex influence on a part remote from the place of application they are termed **counterirritants.** In the application of counterirritants the sensory nerve endings lying beneath the surface are irritated and this promotes relief of congestion and inflammation in either an adjoining or a distant part.

Drugs, heat, and cold are used as counterirritants and their principal purposes are to relieve congestion and inflammation as in tonsillitis, pneumonia, and headache; to promote absorption of serous effusions, as in pleurisy, and exudates around joints; to stimulate nerve centers in collapse; and to increase peristalsis and thus overcome tympanites. Substances used as counterirritants produce different stages of irritation according to their strength and the length of time applied and are known as *rubefacients* or reddeners, which cause the superficial vessels to dilate and redden the skin; *vesicants* which produce a blister; and caustics or *escharotics,* which cause a burn or sloughing. (*See* section on Materia Medica.) Rubefacients are sometimes spoken of as first degree irritants, vesicants as second degree irritants, and escharotics as third degree irritants.

The rubefacients in general use are heat (both dry and moist), mustard pastes, flaxseed poultices, stupes, cupping, and certain liniments. Unless special care is exercised in the use of rubefacients, blisters may be caused which, unlike those resulting from vesicants, may be very slow in healing, and may become infected. Substances employed as rubefacients may be classed as physical (heat and cold), mechanical (cupping, friction, pressure, etc.), and chemical (mustard, iodine, turpentine, ichthyol, etc.). Rubefacient counterirritation by heat usually is produced by the use of hot-water bags, hot-air baths, compresses, poultices, stupes, and by electric-pads. Such *hot applications* are applied for the stimulating effect (heat expands the tissues and thus increases hyperæmia to a greater degree than any of the other counterirritants). Moist heat induces softening of the tissues and at the temperature attained by the use of poultices, if applied directly over an inflamed area, will favor suppuration. For this reason the use of poultices sometimes may produce harmful results. Moist heat is more penetrating than dry heat.

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Hot-water bags.—The water must not be hot enough to scald; the bag should be half full; superfluous air should be forced out of the bag and water appear in the neck before the cap is screwed on; an uncovered hot-water bag should never be given to a patient, and care should be taken that a blanket intervenes between the covered bag and the body of an unconscious patient. Post-operative patients require special care when hot-water bags are applied and should not be left alone while the hot-water bags are in the bed. An attendant never should take a patient's word concerning the temperature of a bag, but should judge for himself and carefully watch the skin for reaction. Be sure the hot-water bag does not leak.

The use of *electric pads* requires important precautions. When these appliances are used make sure that the insulating material around the wires is intact; otherwise the bedclothes may be set on fire. It should be remembered that if the pad is used continuously for any length of time its temperature will increase and it may burn the patient, the heat causing the perspiration to scald him.

Hot wet dressings should be applied in the form of fluffed gauze or rolled gauze compresses wrung out of a hot antiseptic or sterile solution. They should be applied and covered with thin oiled silk or rubber sheeting to protect the bedclothes and mattress, and a hot-water bag should be placed outside of the rubber sheeting to maintain the heat. Precautions should be taken against permitting a wet dressing to become cold, especially at night; carelessness may result in the development of serious complications.

Poultices are hot, soft, moist pastes prepared for local, external application. Flaxseed meal is the substance generally used for poultices because when cooked or par-boiled it retains heat and moisture for a considerable time. The following articles should be at hand: Flaxseed meal, saucepan with boiling water, oiled muslin of sufficient size to cover the poultice when finished, old muslin cut 2 inches larger than the required size of the poultice, hot-water bottle, 2 dressing towels, tablespoon, spatula, soda bicarbonate, a binder, and a light wrap of flannel for shoulder or chest covering. When the water (one-half pint for medium-sized poultice) is boiling, gradually add the flaxseed, stirring constantly with the tablespoon to keep the mixture smooth and without lumps. When of the right consistency the paste may be easily scraped from the sides of the pan. At this time add a small amount of soda bicarbonate and with the tablespoon beat the poultice until it becomes fluffy; then pour it on the muslin and with the spatula spread it quickly to within 2 inches of the edges. Turn the edges back over the paste and cover with one layer of muslin, the edges of which are folded under the foundation of the poultice. Fold the poultice in a warm towel or a folded newspaper, carry it on a hot-water bag to the bedside, and after testing its temperature against the cheek apply it to the patient who has been previously prepared. The patient's skin should be oiled and the poultice applied in the same manner as a stupe, except that after making sure that the poultice is not too hot the binder is adjusted and left in place for 30 to 45 minutes, or as ordered, when another poultice is applied. On removing a poultice put it in a waste receptacle; never use it a second time. After removal of a poultice the skin surface should be dried, observed as to the degree of redness, and covered with a layer of warmed cotton which should remain until the next poultice is applied or its removal is directed. After use the equipment should be cleaned and placed in order. Always put water in a cooking pan as soon as the paste has been taken out.

Stupes, or *hot fomentations*, are prepared by placing two layers of flannel in boiling water, wringing as dry as possible by means of a canvas or towel

and applying directly to the skin, which has been greased with petrolatum to prevent blistering. The flannels are covered with a light rubber sheeting or heavier flannel and kept in place with a bandage or binder, and are changed frequently. They usually are allowed to remain over a period of from 20 minutes to 1 hour, or as directed. If the stupes are ordered over a broken surface, sterile gauze should be used and wrung dry by means of a sterile towel, observing the strictest asepsis in regard to water, hands, material, etc.

In preparing stupes for application to the abdomen the following equipment should be at the bedside: Electric stove and basin of boiling water, piece of oiled muslin and three pieces of flannel or old blanket; binder, chest protector, and three towels; vaseline or oil, stupe wringer, and waste receptacle; safety pins; and, if turpentine stupe is to be given, a medicine glass, mixing rod, turpentine, and olive oil. Have basin and electric plate near, but at a safe distance from the patient. Fold one piece of flannel double and, placing it in stupe wringer, immerse it in the boiling water, leaving the ends of wringer out of the water. Protect the patient with a chest protector or lightweight blanket over his chest, turn the bed-covers down, and cover the abdomen with a warm, dry flannel and oiled muslin. Protect the bedclothes with towels at upper edge and beyond the area of application. Remove the flannel from the boiling water, wring it as dry as possible, and give the folds a quick shake to somewhat cool the stupe. Before applying, test the temperature of the flannel by laying against the cheek, then raising the abdominal cover slightly, slip the folded stupe under it, and over the abdomen. After applying the stupe raise it slightly and lower it a few times if the patient complains or if the skin becomes too red. Prepare another stupe in like manner and replace the first when it cools. Repeat applications for the length of time prescribed or until the purpose is accomplished. On completion of the treatment cover the abdomen with a warm, dry flannel and secure the binder, which has been previously placed in position. Remove equipment and make it ready for further treatment.

When *turpentine stupes* are to be given it is desirable to mix the turpentine with olive, cotton-seed, or mineral oil in the proportion of 1 part of turpentine to 2 of oil for an adult and stir well so that there is no danger of globules of turpentine remaining free. After heating apply the mixture to the abdomen with the tips of the fingers which prevents leaving a stray drop remaining to burn the patient when the heat is applied. Then apply the heated flannel as previously described, making 2 or 3 applications of the turpentine and oil during the procedure, if desired, ascertaining each time that they are warm and well mixed.

Mustard sinapisms, or plasters, are used in the form of a mustard paste or mustard leaf. The paste is made from flour and warm water, into which mustard is stirred in the proportion desired, usually varying from one-eighth to one-half, the latter proportion for applications to the chest. If the skin is sensitive the white of an egg should be mixed with the mustard. Spread the paste on thick muslin, turn in the edges, and cover the surface next to the skin with gauze. This application generally is allowed to remain not longer than 15 minutes, and should be watched carefully. Certain individuals blister more rapidly than others. After removing, if the skin is very red, a bland ointment should be applied. If the official mustard leaf is used, it should be dipped in tepid water, allowed to drip, applied directly to the skin or on a layer of thin muslin, allowed to remain for 5 or 10 minutes, and watched carefully to avoid blistering. After removal the surface should be dried and kept covered until all redness has disappeared.

If the plaster is made some distance away from the patient it should be placed on a hot-water bottle to be carried to the patient's bedside. The action of a mustard plaster is due to the presence of an irritant volatile oil which is released when mustard is combined with water.

Iodine is applied as a counterirritant by "painting" the area to be treated with a solution of the desired strength and allowing it to dry. Blistering is to be avoided by making certain: That the solution used is of the proper strength; that the patient is not idiosyncratic to iodine (some skins cannot bear a single application of iodine without being burned); that dressings are not applied over surfaces to which iodine has been applied; and that iodine is not applied in conjunction with bichloride of mercury. A second application of iodine should not be made too soon nor continued applications made on consecutive days over too long a period.

Cupping is the application of glass cups in which a vacuum can be created to parts of the body surface to obtain hyperæmia and to relieve congestion in underlying parts. The vacuum is created by heat or by suction. In creating vacuum by heat great care must be taken to avoid heating the rim. A cupping glass should never be forcibly removed, but by gentle insertion of the finger tip under the edge of the glass the vacuum can be destroyed and the cup then removed easily.

Cold usually is applied as a counterirritant in the form of ice, iced water, and iced solutions by the use of ice caps, ice coils, compresses, local baths or irrigations.

In using *ice caps* the ice should be broken into pieces about the size of a walnut, using a canvas bag and mallet. After half filling the bag the air should be expelled by squeezing and the cap securely screwed down. The bag should not be more than three-quarters full and always should be covered with gauze. After use the surface of the bag should be washed with a disinfectant and hung up to dry before putting away.

Cold compresses consist of several layers of gauze or absorbent cotton immersed in cold water or iced water, wrung out to remove the excess water, and applied to the desired part. These compresses must be changed very frequently in order to keep the part cold. Eye and throat compresses are the most commonly used cold compresses. Absorbent cotton should be used for the eye compresses, the pad consisting of several layers of cotton a little larger than the eye in size but not large enough to extend over the bridge of the nose. If both eyes are to be treated, separate pads and separate basins of iced water should be used for each eye. When there is discharge from the eye the same compress must never be used more than once. A receptacle should be provided, in which to throw the soiled compresses. A compress should not be allowed to remain on a part until it becomes warm.

Vesicants, or *epispastics*, are agents that produce blisters and usually are applied to cause absorption or removal of inflammatory waste after true inflammation. A common vesicant is cantharides (cantharidal collodion or plaster). The skin should be aseptically prepared before the application of cantharides; as this drug is absorbed through the skin and it is eliminated through the kidneys, the urine should be watched for 24 hours following for symptoms of nephritis. A definite statement should be obtained from the medical officer regarding the size of the area to be treated, usually not more than one-half inch to 2 inches square, and this area should be outlined in oil. A thin coating of cantharidal collodion is applied, using a sterile swab, and allowed to dry. After the blister has formed, usually in from four to eight hours, the collodion should be removed by patting it gently with a sterile

gauze sponge wet with ether, taking care not to break the blister in removing the plaster, and any adherent particles of collodion wiped away with oil and a sterile dressing applied. The blister should not be opened unless it is so ordered, in which case a slit should be made in its lower edge with a sterile scissors and the escaping fluid caught in sterile gauze. Slight pressure should be made above the blister with a sterile gauze sponge to promote complete discharge of fluid.

The type of counterirritation produced by *escharotics* is very prolonged in its action and is not greatly used. The therapeutic uses are: To produce death and sloughing of tissues, to stimulate healing, to neutralize and prevent absorption of poisons from snake bite, dog bite, etc., and to remove surface growths such as warts, etc. Chemical agents commonly used as escharotics are acids such as sulfuric, nitric, salicylic, and glacial acetic; alkalies such as potassium and sodium hydroxide; metallic salts such as silver nitrate, copper sulfate, zinc chloride, burnt alum, and arsenic; carbon dioxide (liquid or solid), and the cautery. Escharotics must be applied with great care so as to reach the local area only. When the desired result has been obtained the action of the caustic is checked by neutralizing it.

Among the therapeutic treatments that rank high in importance and which require more than ordinary skill in their administration are the **enemata.**

An enema, or clyster, is the injection of fluid into the lower bowel by way of the rectum for therapeutic or nutritive purposes, and is usually classed as *evacuant* or *retention.*

The general object of this form of treatment is to relieve constipation by cleansing the lower bowel; to soothe, nourish, or stimulate; to destroy microörganisms or worms; to act as an astringent; to relieve distension from gas; to supply tissues with needed fluid; to supply medication locally, or to the general system; and to increase or decrease body temperature.

The following routine equipment is required for giving an evacuant enema: A bath blanket or sheet, an extra rubber sheet and covering; irrigator standard; irrigating can, fully equipped with tubing, connecting tubes, tip and rectal tube, stopcock or regulator, all connected ready for use; pitcher of solution, properly prepared and of required temperature; bedpan and cover, lubricant and wooden tongue depressor; kidney basin; bath thermometer; gauze compresses; mixing spoon; basin with warm water for cleansing patient following enema; towel; bed screen. The following points should be remembered: Have all necessary articles assembled at the bedside; have patient properly screened; never expose patient; have mattress well protected with extra rubber sheet and a sheet.

The simple soap-suds enema is the one most frequently given, and for this there should be kept on hand a jar of liquid soap, prepared by boiling or dissolving some pure soap in sufficient water to form a soft jelly. To prepare the enema dissolve two or three ounces of this jelly in a pitcher of water at temperature of 108° F., mix well, and remove froth. If pieces of soap are used, after water becomes sufficiently soapy remove pieces to prevent clogging of the tubing. Carry solution, covered, to the bedside, where proper assembly of articles and preparation of bed and patient have been previously made.

When giving an enema replace the upper bedclothes with a blanket or sheet; draw the patient to the right side of the bed, turn him on his left side, drawing up and flexing somewhat the right leg, and drawing the left leg down and back somewhat; have the right amount of solution at right temperature; lubricate the tube well to make insertion easy, and to prevent injury; expel

all air from tube by allowing the solution to flow through until of the right temperature; pinch the tube and insert it in the rectum. Use no force when introducing the tube or tip. If the sphincter muscles are tense, encourage and assist the patient to relax by reassuring him and explaining the necessity of so doing; remove pressure on the tube and allow the solution to enter slowly; if the patient complains of pain, and gas is heard rolling, shut the clamp on the tube for a moment and move it slightly back and forth, at all times urging patient to relax and prevent premature expulsion of the enema. Frequently where gas has accumulated behind the fæces some will escape about the tube or, forcing back the fluid in the tube, escape through it in bubbles in the top of the can; following this relief from escape of gas, more fluid may be injected until a pint or more has been given. Urge the patient to retain this for 15 or 20 minutes, or as long as he can without distress, when it should be freely and voluntarily expelled. Occasionally a patient, because of weakness, constriction of muscles, or from temporary paralysis of peristalsis, is unable to expel the enema. When this occurs hot stupes are sometimes used to stimulate muscles and relax rigidity, and if these are not effective the fluid is siphoned off by inserting the rectal tube and draining the fluid into the bedpan. When this is necessary the object of the enema has been accomplished only partially, for peristalsis has not been stimulated and the abdominal muscles have not been relaxed as they should have been. The resulting relief is much less; in fact, this is sometimes a dangerous symptom as, when following an operation, it may indicate peritonitis; or in typhoid it may indicate a perforation of the intestine. Sometimes when too small a quantity has been taken or when the system, needing fluids, has absorbed much of the enema, a second enema will have to be given. When this is necessary use the routine procedure, but watch carefully for any untoward symptoms. Stop immediately and siphon off fluid, if excessive discomfort, distension, or other unpleasant symptoms occur. When the enema has been expelled remove the bedpan, cover it and take it from the ward immediately. Thoroughly cleanse the patient, remove the extra rubber and draw sheets, replace pajamas, straighten and tidy the draw sheet, and replace the bath blanket or sheet with the bed covers, leaving the patient comfortable and clean. Remove all utensils and return them to their accustomed places in readiness for the next time needed. Air the room thoroughly, and make a complete and correct record of results of the enema on the bedside notes. The rectal tube or tip should never be placed in the enema can, but removed from tubing and placed in a receptacle for that purpose.

Retention enemata are given for the purposes of: 1. Supplying a patient with food or fluid when he is unconscious, unable to swallow, cannot retain food or fluids taken by mouth, or his body is dehydrated; 2. Administering medicines; 3. Administering local applications to the mucosa of the rectum and lower bowel; and 4. Administering anæsthetics. Barium sulfate is sometimes introduced into the lower bowel in this way so that X-ray photographs of this part of the intestine may be taken.

The amount of fluid given in retention enemata varies, 6 to 8 ounces being the usual maximum amount when given within a short period, but may be considerably more if given drop by drop over an extended period of time. The temperature of the fluid should ordinarily be 100° F. Retention enemata should be given strictly according to specific directions as to quantity, rate of speed, and length of time to be retained. Before giving ascertain that the lower bowel has been emptied sufficiently long to allow peristalsis to have subsided. For small amounts of fluids a rubber catheter with funnel attach-

ment may be used. Following the introduction of the fluid a hot compress applied with pressure to the anus for a few minutes will often assist greatly in preventing expulsion of the enema. Remove the catheter slowly, pinching the tube or applying the shut off before and during the removal of the tube. *Nutritive enemata* consist of specially prepared foods in liquid form. They are prepared according to various formulæ, depending upon the conditions for which given, and the preference of the medical officer prescribing. *Sedative enemata* usually contain some drug or special preparation for quieting or soothing and are given according to specific directions. The patient should be made as comfortable as possible before the sedative enema is given so that he may be ready for sleep following it. *Astringent enemata* consist of hot water (120° F.) or of some astringent preparation for drying up or lessening intestinal secretions or for stopping hæmorrhage. They are given under definite instructions from the medical officer. *Carminative enemata* are occasionally used. These are of many types but two are of sufficient importance to be mentioned here. These are the turpentine enema and the milk and molasses enema. These cause an increased expulsion of flatus. Turpentine enemata are made by mixing 1 dram (1 teaspoonful) of turpentine with 1 ounce of cotton seed or mineral oil. This mixture is then added to 1 pint of soap suds and is stirred constantly while it is being given. Milk and molasses enemata are made up of equal parts of milk and molasses (usually 7 ounces of each). This mixture should be retained by the patient as long as possible and then followed by a soap suds enema.

Enteroclysis, also termed colonic flushing or rectal irrigation, is the introduction of a large amount of fluid into the colon by way of the rectum, provision being made at the same time for a return flow of all fluid not absorbed. The object of enteroclysis is to cleanse the colon and rectum of toxic, irritating, or putrefying material, and to remove mucus. The equipment required consists of a two-way rectal tube of rubber or a satisfactory substitute; a rubber operating pad (commonly called a Kelly pad); a rubber sheet or newspaper to protect the deck; a bucket to receive the outflow; sufficient solution with convenient means of adding it as needed to the contents of the irrigating can; and the remainder of the equipment the same as listed under routine equipment for enemata. A cleansing enema is given before starting enteroclysis to free the colon and rectum of fæces; following this the inflow and outflow go on simultaneously; the introduction of two tubes, instead of a two-way tube, is accomplished by inserting the inflow tube for 3 inches, then inserting the outflow tube just inside the rectum, then gently pushing both tubes 3 inches farther in. All tubes inserted in the rectum should be well lubricated.

All routine precautions for enemata are essential in giving enteroclysis and in addition care should be taken to provide adequate means for the disposal of the unusual quantity of solution; the return-flow tube should remain in until the outflow ceases; the contents of the can should be replenished as often as necessary until the required amount has been given or the purpose accomplished, and at no time should the can become empty and air enter the tube. The result should be noted and recorded accurately so that the medical officer may be fully informed as to the effectiveness of the treatment.

Instead of the soap-suds enema for cleansing, some medical officers prefer to use either physiological salt solution or a 2 per cent sodium bicarbonate solution for this purpose as it is less irritating.

Two important therapeutic treatments frequently given are *gastric lavage* and *gavage.*

Gastric lavage is the washing out of the stomach. Its object is to remove poisons, to remove irritating substances or those causing nausea, vomiting, or distension, and to relieve congestion. It should be remembered that except in cases of poisoning, a lavage must never be given without an order. When giving a lavage reassure the patient, instruct him to remove any false teeth, to breathe naturally through the mouth and nose, to hold the head slightly forward and lowered, and, as the tube is introduced, to contract the throat as in swallowing. Never force the tube, but take sufficient time, working quietly and encouraging the patient, and if the patient complains of severe pain when fluid is introduced, or blood appears, stop treatment immediately and report to the medical officer. Never allow the funnel to become empty during the introduction of the fluid; do not tickle the back of the patient's throat when introducing the tube. Insert the tube only to the mark (16 to 18 inches), as this indicates the limit the tube should be inserted. See that clothing is loose about the neck.

The necessary equipment consists of a lavage tube coiled in ice, a pitcher of the prescribed solution at a temperature of 105° F., a kidney basin; gauze handkerchief; 2 rubber aprons; white enamel bucket; towel; mouth gag or tongue depressor; rubber sheet, or a newspaper to protect the deck; and a lubricant, such as glycerin or liquid petrolatum. The solution used is usually 3 to 5 per cent soda bicarbonate, 2 per cent boric acid, or plain water. When ready to introduce the tube place the patient, if he is conscious and able, in a sitting position, explain the procedure and reassure him. Thoroughly wash the hands and take a position to the right of the patient, give him a gauze handkerchief and a kidney basin, and protect him with a rubber apron or sheet covered at the neck with a towel.

A bucket should be convenient for the return flow. Take the tube from the ice and expel all air from it by stretching it, and pinching it at the funnel end, 2 or 3 inches from the end to be inserted. Hold the tube so curved that it will not strike the back of throat as it is inserted. Insert just above the tongue and instruct the patient to swallow just as he would swallow food. Glycerin applied to the tube makes swallowing easier. Pass the tube steadily but without force until the mark on the tube reaches the lips. Try to make the patient fully understand that if he relaxes and breathes easily the tube will be passed without discomfort while if he is rigid or struggles, it will be passed with much more difficulty, and with far more discomfort to him. Hold the funnel about 6 inches above the patient and pour in the solution, always refilling when the funnel becomes half empty. When about a pint of fluid has been given invert the funnel quickly, while still half full, to below the level of the stomach, for siphonage, instructing the patient to lean forward at the same time. Repeat the procedure until the required amount has been given, or until the return flow is clear. Then pinch the tube and withdraw it quickly. Place the tube and funnel in the basin before releasing pressure on it to prevent release of the contents on the patient or the deck. Give the patient a mouth wash and bathe his face with cool water. Remove equipment and set it in order. Rinse the tube and funnel with clear cold water to thoroughly cleanse it from all deposits, then boil them before replacing on tray. If lavage is given in the absence of the medical officer, save the return flow for his inspection. Record the time of treatment, the amount of solution given, and the amount and appearance of return flow.

Gavage signifies the introduction of liquid food into the stomach through a tube. It may be oral (through the mouth) or nasal (through the nose). Gavage is indicated following operations upon the mouth; in cases of insanity

or excessive weakness; in tetanus; in cases of spasm or stricture of the œsophagus when the patient is unable to swallow; during continuous unconsciousness; and to administer an antidote or other medication.

The procedure for oral gavage is the same as for lavage, except that the fluid introduced is in smaller quantity and is allowed to remain in the stomach instead of being siphoned off. After introducing the tube, wait until all muscular contractions have ceased and the sensation of gagging has been overcome; then slowly pour in the food, pinching the tube before all food has left it, to prevent air entering the stomach, or food being drawn into the trachea. Withdraw the tube quickly. Have patient lie down and remain quiet until all danger of vomiting is past. Clean and replace equipment as following lavage.

SURGICAL NURSING

Surgical nursing is primarily concerned with the operating room and surgical operations, the preparation of surgical dressings and the dressing of surgical wounds, the preoperative preparation and postoperative care of surgical patients, and minor surgical procedures involved in the special nursing care of certain more or less surgical conditions. Reference should be had to the section on Operating Room and Surgical Technique for the discussion of certain parts of surgical nursing.

Preoperative preparation.

The details of the *preparation of a patient for an operation* vary somewhat in different hospitals, but the general principles are the same. Always bear in mind that overtiring or exciting a patient previously will cause unfavorable reaction both while he is going under the anæsthetic and while recovering from it. A patient should never be teased or alarmed while waiting for this ordeal. Usually patients for operation are sent to the hospital 24 hours before the operation is to be performed so that the necessary preparations may be made without haste and without exhausting the patient. The attendant, while preparing the patient, should encourage him, keep him in good spirits, and in various casual ways inspire him with confidence in the surgeon, the nursing staff, and the hospital in general.

Much of the *preoperative preparation* of a patient for operation takes place on the day before the operation is scheduled. The patient should, if he is able, take his own bath and shampoo, but he should be inspected afterward to make certain he is thoroughly clean. Patients having an elevation of temperature should be given a cleansing bath in bed.

In the *local preparation* for most operations, except in definite emergency, the site of operation is shaved and thoroughly cleansed after the bath. The area prepared should extend beyond the specified point of incision far enough to prevent danger of contamination from adjacent skin surfaces during the operation, and to allow sufficient sterile space for a second incision or change of site of incision. For most areas the general preparation varies but little. Most surgeons, however, have their own special routine for preoperative preparation and for postoperative care, and this is posted in their wards or given and signed by them for each individual case. In the preparation of abdominal cases special attention should be given the cleansing of the umbilicus. Using a small applicator well padded with absorbent cotton, the attendant should cleanse well within the folds with green soap and water, clear warm water to remove all traces of soap, and then dry with alcohol or ether. The stomach, intestine, and bladder should be empty to prevent embarrassment and the contamination of the patient and operators by the involuntary discharge of the contents of

those organs when the patient becomes relaxed under the anæsthetic; to prevent accidental incision of bladder or intestine because of their distention; to prevent choking from aspirating fluid or food during vomiting, which frequently occurs during the administration of an anæsthetic when the stomach is full; also to prevent unnecessary discomfort following an operation, from the accumulation of gas due to putrefaction of partially digested food in the intestine. Usually a cathartic is ordered the night before operation. Frequently this is castor oil because it accomplishes thorough evacuation and does not overstimulate peristalsis.

Early on the *morning of operation* a soap-suds enema is given, and repeated, if necessary, to secure a clear return flow. The enema is given slowly, and should be retained for a few minutes to assure a thorough washing out of the lower intestine. It should not be repeated more than once (except for some definitely specified reason), as distention might follow, or excessive peristalsis be stimulated which might be difficult to reduce or control before the time scheduled for the operation. Following the enema the patient should be made clean and comfortable and allowed to rest until time to go to the operating room. Frequently a surgeon will order an enema at 8 p. m. the evening before an operation, in addition to the enema on the morning of operation. This aids greatly in the thorough cleansing of the intestinal tract and in the consequent comfort of the patient following the operation. Except in special emergency an enema should not be given to a patient just before going to the operating room.

On the morning before and the morning following an operation under a general anæsthetic a specimen of *urine* is sent to the laboratory for examination.

On the day preceding the day of operation the *diet* should consist of light nutritious food that can be quickly digested and readily assimilated, leaving little residue in the intestinal tract. No solid food should be given within 12 hours of the operation. If the patient is weak and requires nourishment, strained soups and broths may be given up to six hours before the operation, after which nothing should be given by mouth. Water should be given freely up to within six hours of an operation, as it flushes the kidneys and clears the pores of the skin. When an operation is to be performed under local anæsthesia a light breakfast is often given on the day of operation.

Before a patient is taken to the operating room any money or jewelry he has should be listed and turned over to the proper authority for safekeeping. Artificial teeth should be removed and placed in boric-acid solution in a labelled receptacle. His pajama coat should be reversed and he should urinate, the amount of urine and the time voided being recorded on the information sheet accompanying him to the operating room as well as on the Clinical Notes. An opiate by hypodermic injection is usually given from 10 minutes to half an hour before the patient leaves for the operating room, depending entirely upon the surgeon's order. The time and amount given are recorded on the Clinical Notes, and on the information sheet for the operating room. When the patient leaves for the operating room on the wheel stretcher he is well wrapped with blankets, the head being usually covered with a special operating-room cap or with a towel to protect his head from drafts and to absorb excess of moisture during anæsthesia. Care should be taken that the patient is neither teased nor alarmed as he leaves for the operating room but is cheered and reassured. Record on his Clinical Notes the time of departure for the operating room. In placing the patient on the operating table care should be taken to see that his position on it is as comfortable and unstrained as possible. A small pillow or pad under the hollow of the back will aid

greatly in preventing undue strain which results in the severe backache so frequently complained of by postoperative patients, sometimes far exceeding the pain and discomfort of the operation itself. Patients with large, heavy shoulders require greater elevation under the head than do others.

The **postoperative care** of a patient begins with his return from the operating room. When a patient arrives in the ward recovering from a general anæsthetic, place him at once in a well-warmed ether bed in a warm room with sufficient ventilation but without drafts; do not leave him alone until he fully regains consciousness, because of the danger of swallowing his tongue, choking on aspirated mucus, becoming chilled, and other accidents which might happen to an unconscious patient. Take pulse and respiration every 10 to 15 minutes during the first two hours, and longer if there is any reason for so doing; if no reason for alarm exists, take every half hour for the next hour or two and then every 2 to 3 or 4 hours. Record them as taken, stating the time. Until the patient has reacted, hold his jaw upward and forward firmly, but without rigid pressure as too great pressure might cause facial paralysis, to prevent his tongue from falling back in the throat. Turn the head somewhat to one side to make it easier to care for the vomitus and to remove mucus from the mouth and throat. When vomiting occurs raise the head slightly and tip it forward to the side, placing the kidney basin under the angle of the jaw, and, supporting the patient's head with one arm and hand, with the other hand wipe his mouth and face and remove all mucus possible from his mouth, using squares of gauze. If violent retching occurs in an abdominal case, apply firm pressure over the region of the wound to prevent undue strain on the sutures and the surgically-injured muscles. Dry the face frequently during the period of excessive perspiration following the anæsthesia; and dry the body and replace the damp linen as soon as it is wise to disturb the patient, taking great care to avoid exposing any part of the body surface. Give nothing by mouth until ordered by the surgeon in charge of case, and allow no water within reach of patient until he is permitted to have it freely. If the mouth is very dry swab the mouth occasionally with iced water. Persistent vomiting, if not relieved by simple measures such as a hot-water bottle, small amounts of cracked ice, or *hot* water, may necessitate gastric lavage. This is given only by the ward medical officer or under his direct supervision. When liquids are first given they must be dispensed either hot or cold, never lukewarm. Many surgeons, as a routine procedure, order 500 cc of fluid by proctoclysis, to be administered as soon after the patient's return from the operating room as is practicable, for all abdominal cases that have had a general anæsthetic. The kidneys are thus furnished with fluid to assist in flushing and in elimination of waste, and the bladder is stimulated to action and discomfort from thirst is lessened. Retention of urine is very common after an operation. When a patient does not void within 8 or 10 hours following an operation, especially if he complains of any discomfort, the surgeon should be notified after all simple means to induce patient to void have been tried. Catheterization may then be ordered, and is performed by or under the supervision of the surgeon.

Special complications to watch for, guard against, and report promptly when discovered in postoperative cases are: *Hæmorrhage*, indicated by weak, rapid pulse, pallor, subnormal temperature; excessive restlessness; drawn, anxious expression; thirst and air hunger (gasping for air); blood-stained dressings or blood in stools, urine, or vomitus; *collapse*, indicated by excessive weakness; cold, clammy skin; weak, thready, almost imperceptible pulse; unconsciousness; *temporary paralysis of peristalsis*, indicated by excessive distension, failure to expel flatus by rectum, respiratory and heart symptoms from pressure of

gas against the diaphragm, and by symptoms of shock; and *peritonitis*, a complication which frequently develops following an operation for an abdominal septic condition and sometimes following a clean operation which has become infected. The symptoms of peritonitis include many of the foregoing, and in severe cases the restlessness, rapid respirations, and feeling and appearance of apprehension are extreme. This condition is the most trying, as even in fatal cases consciousness continues almost to the last.

In the *care* of hæmorrhage inform the medical officer immediately after the first symptoms are noted. Do not leave the patient alone; stand by and reassure him. If evidenced by external bleeding, reenforce outer dressings and, where practicable, apply tight bandage while waiting for the surgeon. Following tonsillectomies elevate the head and shoulders and apply an ice-collar to the throat. The *care* of collapse requires the immediate reporting of the condition to the medical officer, the prompt application of heat, and stimulation as ordered. To *care* for paralysis of peristalsis report the first symptoms noted to the medical officer. Relief measures such as insertion of a rectal tube, turpentine enemata, hot stupes, external heat, etc., must be taken at once, otherwise the paralysis may continue and serious results follow. Prompt recognition and reporting of symptoms are essential in the *care* of peritonitis and prompt and efficient carrying out of all orders are necessary for the relief of the patient. *Fowler's position* is almost always ordered as a routine measure in abdominal pus cases in order to promote free drainage from the abdominal cavity, and in empyæma cases to keep the fluid in the chest at the lowest level. The degree of elevation is 40° to 50° and should not be more, as the greater elevation would be too trying; it should not be less, for then drainage would be less free.

In all post-operative cases the patient should be warned of the danger of infection incurred by putting his fingers under his dressings to adjust them or to scratch himself. In drainage cases the patient should be placed in Fowler's position as soon as practicable. Fluids should be forced as soon as the patient is able to take them by mouth, and when unable to take fluids by mouth they should be given by proctoclysis, either continuously or at intervals. When there is free discharge of pus the dressings should be changed as frequently as required to keep the wound clean and the skin surface free from irritation.

Care of the genito-urinary tract is very important in the nursing of post-operative cases and may involve catheterization and bladder irrigation. *Catheterization* is a word generally used in connection with the withdrawal of fluid from a body cavity, particularly with reference to the removal of urine from the bladder or ureters. The purposes of the latter type of catheterization are: To relieve the discomfort of a patient when, because of retention he is unable to void; to obtain a sterile specimen of urine; and to empty the bladder when urination is involuntary. For catheterization the following articles are required: Sterile boric-acid solution; sterile dressing bowl, sterile rubber catheters (sizes 10 and 12), sterile lubricant (oil), sterile sponges, two sterile dressing towels, sterile gloves and gown, urinal or basin to receive urine (sterile when so required), and a waste receptacle. Remember, always, to use strict aseptic measures in preparing for and carrying out this procedure; never to catheterize until all routine means of inducing patient to void have been exhausted and then only when ordered by a medical officer; to have hands surgically clean and not to touch the catheter on or near the end to be inserted nor to let it come in contact with anything unsterile; to have good light.

After properly cleansing the glans and protecting with a sterile sponge, placing sterile towels, the attendant disinfects his hands, puts on sterile gloves,

lubricates the catheter, and introduces it without force until it enters the bladder and the urine starts to flow. When the bladder is empty remove the catheter carefully, and apply a sterile compress to urethral exit. When catheterizing observe the following precautions: Never use force; have all articles used sterile, and hands surgically clean as improper care and the introduction of bacteria into the bladder or injuring the mucous lining of bladder or urethra may give rise to an inflammatory condition which is very hard to cure. If the bladder is distended greatly, not more than 600 cc of urine should be removed at once, as the bladder walls would collapse; enough urine should remain in the bladder to keep its walls separated until they have gradually contracted to normal size. Measure the urine obtained and record the amount on Clinical Notes, together with the time of catheterization.

Expedients that should be tried to cause voluntary micturition before catheterization is resorted to are: Placing the patient on a bedpan and pouring warm water over the pubis; applying hot compresses or a hot-water bag to the pubis; if the patient is near a bathroom, allow water to run from a faucet, in order that he may hear the sound of running water; give plenty of liquids to drink, if allowed, especially mineral waters, and lemonade; and with the medical officer's permission only, allow the patient to sit up, with support. This latter procedure must not be permitted without the medical officer's consent.

Bladder irrigation is the washing out of the bladder. The equipment consists of the catheterization tray, a silver return catheter, or a Y-connecting tube with stopcocks; sterile irrigating can with sterile solution (usually boric-acid solution) at required temperature, sterile tubing with clamp for regulating inflow attached to can which is covered with a sterile towel, and a piece of sterile tubing to attach to the Y-tube for the outflow; a rubber operating pad or other protection for bed, and bucket to receive return flow; a sterile solution thermometer. Prepare the patient as for catheterization and hang the irrigating can about 12 inches above the patient's hips. Place the patient on the pad, the free end of which extends into the bucket at side of bed. Attach a piece of sterile tubing to lower projection of the 2-way catheter, with stopcock shut; allow solution to run through tubing on can until of the required temperature and until all air is expelled from tubing, which is then attached to the Y-tube, the stopcock of which is closed. Open the cock on outflow and catheterize patient, again closing cock before any air has entered the tubing; open the cock on inflow and allow half a pint of solution to flow into the bladder, after which open the stopcock on the outflow and allow solution to flow in and out until the desired amount has been given. Because of the restriction of the outflow at the beginning there is at all times in the bladder sufficient solution to thoroughly bathe the bladder walls. Before all solution has left the can, apply the shut-off. Allow all the solution to flow from the bladder, and finish treatment as following catheterization.

Surgical dressings and dressing surgical wounds.

The purposes of surgical dressings are to prevent contamination of the area surrounding a wound and its consequent infection, to keep the wound clean and protect it from mechanical irritation, to absorb discharges and thereby protect the patient, his clothes, and his bedding from becoming soiled.

Surgical gauze and absorbent cotton are the materials used most frequently in the preparation of surgical dressings. The particular method for folding the gauze and the shape and size of the sponges and packing used depend upon the preference of the surgeon and the size and type of the wound dressed.

Whatever method is used, one fundamental principle remains the same—that is, all raw edges are well folded in so that no ravellings are free to get into the wound during an operation or dressing. This precaution is especially necessary when dressing abdominal or other deep wounds. Absorbent cotton may be made into small balls, or fluffs, for eye work, etc., or made into pads of various sizes and covered with gauze for use over the dressings of discharging wounds. These pads, unsterile, are used in various ways for padding and protection at pressure points.

There are various kinds of surgical dressings which are designated by names indicative of the kind. The simplest dressing used is the *dry dressing* which consists of dry, sterile gauze, applied to a wound, and held in place by bandage or adhesive plaster. *Wet dressings* consist of gauze moistened with solution and covered with some protective material, as oiled muslin, to help the dressings retain the moisture and to protect the patient and his bed from dampness. Such dressings are kept moist by solution poured in through an aperture left for that purpose or injected in required amounts through tubing inserted in the wound with the outer end extending outside the dressings. *Hot wet dressings* should be applied in the form of sterile fluffed cotton or folded gauze compresses wrung out of a hot sterile solution. After application they should be covered with oiled silk or other similar protective material to keep the moisture from the pajamas and bed clothes, and to guard the wound from the absorption of infectious matter. Over the oiled silk should be placed a binder, bandage, or dressing towel, fastened not too tightly, to hold the dressings in place. Over all a hot-water bag should be placed to keep the dressings warm. Never allow hot dressings to become cold.

Before discussing the *dressing of surgical wounds* it is necessary that one should know the important facts relative to the natural healing of wounds and the conditions which interfere with their healing. For that information *see* under Wounds in the section on Minor Surgery and First Aid.

In the dressing of surgical wounds, whether in the dressing room or at the bedside, there are many important things to be remembered. All necessary equipment for a dressing should be ready on a dressing tray or dressing carriage, there should be ample light, and the patient should be in proper position for his comfort and the convenient dressing of the wound. Always dress aseptic, or clean, wounds before septic, or suppurating, ones, maintain absolute aseptic technique in the dressing of all wounds, and avoid unnecessary conversation during a dressing. When removing adhesive plaster moisten it with ether or benzine, and before attempting to remove adherent gauze moisten it with a sterile solution. When removing adhesive strips pull them quickly toward the wound to prevent pulling or spreading it. Remove the dressings where possible with sterile forceps, seizing the sponge in the center and turning the hand so that the discharge on underside of dressing may be examined. Open packages of sterile supplies quickly and correctly without contaminating the contents with the fingers. The sterile sponges may be tipped from the cover onto the sterile towel or tray without contamination and the attendant's hands thus left free. With clean, sterile forceps (not the ones used to remove the soiled dressings) seize the sterile sponge, moisten it with alcohol, and carefully wash the skin about the wound, always wiping away from the wound, never toward it. In dressing and cleansing a wound never touch with the fingers anything that may be handled with forceps. If necessary to remove a cover from a jar or stopper from a bottle, the contents of which are sterile, be very careful not to contaminate the inner surface of either; if necessary to lay them down, place them with outer surface down and make sure that nothing falls on the inner surface; re-

move sterile contents from the container with sterile forceps, spatula, or other suitable sterile implement and replace the cover as soon as possible. When pouring a sterile or disinfecting solution from a bottle into a wound or onto a sterile sponge, unless the entire neck of the bottle is sterile, wipe off the top and the lip with alcohol or other disinfectant before pouring the solution, and pour a little into a basin before pouring any into the wound or onto the gauze. When lifting or holding a sterile basin of solution never take hold of the edge or allow fingers to dip in the solution. Slip hands well under the basin and hold it steady, being careful to not cough or sneeze, or while talking to allow droplets to fall into the basin.

The preparation for and assisting with a dressing calls for conscientiousness in regard to technique and exactness in attention to detail. The equipment of a dressing tray or carriage varies according to the methods of the surgeon and the general routine of the hospital; but one thing is the same concerning all such equipment—each article has it own place, so that there will be no delay in finding each thing as needed. The tray or carriage is covered always with a sterile field cloth, on which the sterile articles are placed and covered with another sterile cloth, which is turned back or taken off as necessary. According to the number of dressings to be done, the tray should contain: *Instruments.*—Sterile forceps, hæmostats, probes, grooved directors, scissors, sterile syringes, needles, and a sterile flask of solution; *Materials.*—Sterile dressing towels, gauze sponges, pads, and packing, sterile applicators, safety pins, and gloves; *Nonsterile articles.*—On the unsterile shelf of the carriage should be arranged bandage scissors, bandages, adhesive plaster, oiled silk or paper, binders (as necessary), safety pins, rubber operating pad or rubber sheet, and attached to carriage should be a bag or bucket for discarded dressings; *Drugs.*—Iodine, alcohol, sterile vaseline, ether (or benzine); also any special drugs, preparations, or solutions required by the surgeon should be on the unsterile portion of the carriage as should extra packages of sterile gauze, unopened. Instruments required for a simple routine dressing are: One pair of tissue forceps, one pair of hæmostats, one probe, one grooved director, and one pair of scissors.

In a simple routine dressing proceed as follows: After the proper arrangement of the bed linen, pajamas, and shoulder or chest coverings, unpin the binder and turn it back, then loosen the adhesive straps at one side or cut through the middle. Place the dressing carriage conveniently by the bedside. Remove soiled dressings with sterile forceps, which are then discarded or placed in disinfecting solution. With a dry, sterile sponge or sponge dipped in alcohol or other prescribed solution, cleanse the area about the wound, wiping away from the wound, never toward it, and never going over the same area twice with the same sponge. Handle the sponge with sterile forceps, using a fresh sponge each time any area about the edge of wound is wiped. Dress the wound itself as directed, apply fresh sterile dressings, and secure them with bandage or adhesive tape, or with adhesive tape and binder as the case may be. Clean wounds are disturbed as little as possible, and after the first few dressings and the removal of the sutures the dressings are changed only as they become soiled or loose and disarranged. Infected wounds are dressed at least once a day and more often as necessary. The surgical technique of the ward surgeon must be followed in detail by whoever does the dressing.

When a wound is being irrigated, the tubing from the irrigator should be handled carefully to prevent the tip and adjacent tubing from being contaminated. Grasp 6 or 8 inches from the free end. Never squeeze a suppurating wound nor any localized collection of pus, there being danger of bruising the adjacent tissues and causing the infection to spread. Remove sloughs

and stringy fibers of dead tissues from a wound with forceps or by irrigation; never rub out with gauze, because irritation of the tender underlying tissues and spread of the infection may result. When gauze packing is used in a wound do not pack it tightly; it should be loose and fluffy, otherwise it will not absorb the secretions, and drainage will be interfered with. If the skin around a wound is irritated by the drainage, cover the area with sterile vaseline. When there is profuse discharge from a wound the dressings should be changed frequently to prevent spread of infection, unpleasant odors, uncleanliness, and discomfort. Before applying a caustic, such as nitrate of silver, thoroughly dry the area chosen for the application. Before and after doing dressings the attendant should thoroughly scrub and disinfect his hands.

Abdominal paracentesis is a surgical procedure used to draw fluid from the abdominal cavity and for which sterile technique is required. The usual equipment is iodine and alcohol for the skin, a few sterile sponges, 2 or more trocars and canulæ with rubber tubing attached, rubber operating pad or rubber sheet to protect bed, a scalpel, a 2 cc syringe and small needle with 2 per cent procaine solution for skin anæsthesia, and a bucket to catch the fluid withdrawn. The patient must be supported in a sitting position if possible. Sterile rubber gloves and sterile field sheets should always be used. This treatment is frequently necessary in heart and kidney cases in order to relieve the distress caused by the distention following the accumulation of fluid in the abdominal cavity.

Nursing in eye, ear, nose, and throat conditions.

Because of the delicate structures of the eye, ear, nose, and throat, there is required in the treatment of conditions affecting those organs an unusual degree of gentleness on the part of those giving such treatment. Carelessness or roughness may result in blindness, deafness, serious injury to the nose or throat, infection of the sinuses or other adjacent parts, and not infrequently in the loss of the senses of taste or smell.

All treatments of eye conditions must be done with the utmost care, both to avoid injury and to prevent infection. Absolute cleanliness of the attendant's hands and of the apparatus is essential and must be scrupulously maintained.

When giving an *eye douche* or irrigation always have adequate light. Never use force or pressure in opening the lids or in directing the flow of the solution. Never direct the stream of fluid against the eyeball, but gently, at an oblique angle, so that the flow is from the inner angle of the eye to the outer. Tilt the head toward the side on which is the eye to be irrigated. Cleanse the lids from all accumulation of discharge before starting an irrigation. Protect and cover one eye while the other is being treated. When both eyes are being treated, protect each during the treatment of the other, sterilize the hands, and use fresh tips and other equipment for the treatment of the second eye. Never use a swab or eye wipe a second time, but, once used, discard it at once. Never allow an irrigation point or tip to come in contact with the eyeball or lids. Dry gently with absorbent cotton, wiping from the inner to the outer angle of the lids. Thoroughly cleanse and sterilize all points, tips, pipettes, or syringes used, both before and after the irrigation. All such articles used in eye treatments should be reserved for that purpose only. The attendant should properly protect himself from infection, especially where there is profuse discharge, by using goggles, gown, and gloves when necessary.

All possible precaution should be taken to prevent discharges collecting at the entrance to the lacrimal sac, and thus infecting it. Irrigation should be continued until all discharge is removed; in case of inflammation without dis-

charge, it should be continued until the prescribed amount of fluid has thoroughly flushed the eye.

In the *instillation of drops* remember to keep the pipettes or medicine droppers used in this form of eye treatment absolutely clean and use them for nothing else. There should be a pipette for each of the various drugs used and they should not be interchanged. Where available, use special bottles, properly labeled and containing their own pipettes which serve also as stoppers. Drugs used for eye treatments should not be kept with other drugs but kept in a place reserved especially for them. When instilling drops instruct the patient to tilt his head backward and slightly to the side on which treatment is to be given; give him a soft compress or piece of absorbent cotton to catch the overflow of secretion sometimes caused by the instillation. Gently draw down the lower lid until a pocket-like space is formed by the folds of the conjunctiva. Into this space drop the medication, then instruct the patient to roll the eyeball outward, that there may be less chance of the drop striking directly over the pupil of the eye. Release the lid and, as the patient automatically closes the eye and rolls the eyeball, the drop will be distributed over the surface of the eye and over that of the conjunctiva lining the lids. If more than two drops are ordered, remember that the free space about the eye will not accommodate more than two drops, and sufficient time must be allowed after the instillation of that amount to allow the contents of this space to become normal again before the additional drops are put in.

Before the *application of an ointment* to the eyelids the eye and the lids should be cleansed if it is possible and is permissible. The ointment then should be applied with an absorbent-cotton fluff made especially for use in eye cases, or with an eye spatula. If ordered to place the ointment within the eye space, put it on and under the lower lid and draw the upper lid down over the lower.

The *removal of foreign bodies* from the eye may be accomplished in several ways. They may sometimes be washed out by using boric acid solution in an eyecup. When the foreign body can be plainly seen and is not embedded in the cornea or conjunctiva it is often easily removed with an eye fluff, or the corner of a handkerchief or other soft cloth brushed gently over the spot. The naturally increased secretions of the eye when irritated frequently wash out the foreign body without other assistance. Forcible blowing of the nose, with the upper lid drawn down over the lower one, sometimes accomplishes the same end. When a foreign body is embedded in the cornea, conjunctiva, or any part of the eye make no attempt to remove it but send for a medical officer, preferably an eye specialist. In the meantime bandage the eye to keep from increasing the irritation by motion. Emergency treatment before the arrival of a medical officer in case of burns, either from heat, acid, lye, or other definitely known cause, may consist of the applications within and without of sterile oil.

Hot applications or *fomentations* are used to relieve pain and to reduce inflammation. Special points to remember are: Never use hot fomentations on the eye without an order from the medical officer. When applying fomentations to both eyes, be sure to use the same compress on the same eye; and when there is discharge from the eyes never use the same compress twice, take a fresh one each time. Wash away discharges before starting treatment. Assemble all necessary articles at the bedside. Assist the patient to assume a comfortable position, with head slightly thrown back and the eye to be treated somewhat lower than the other eye to lessen the danger of infecting the well eye, and cover the good eye with an eye patch or other protective covering. Protect the patient and bed with rubber sheet and towel and have a paper bag

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or other waste receptacle fastened to the bed or placed conveniently near for receiving all débris. Keep the basin containing the solution on an electric hot-plate with the heat regulated to maintain the solution at the proper temperature. Place a soft compress in a small stupe wringer and put the two in the basin of solution. After cleansing the eyelids of any discharge and applying boric acid ointment to them, take the compress from the solution, wring it out well to prevent dripping and gently place it over the closed eye. A little shake will cool the compress sufficiently, but be certain that, though hot enough to accomplish the desired result, it is not hot enough to injure the tissue or skin. Compresses so small cool very quickly, and during the time of treatment changing them is practically a continuous performance, one compress being always on the eye and another heating in the solution. Following the treatment, dry the eye, make the patient comfortable, remove equipment, cleaning and boiling basins, etc., and leave the tray in readiness for the next treatment. Time and frequency of treatments depend upon the medical officer's orders, which many times designate continuous applications for 10 to 15 minutes every hour or two.

Gonorrhœal ophthalmia is a severe and purulent inflammation of the conjunctivæ of the eye resulting from their infection with the mircroörganism causing gonorrhœa. The infection is especially virulent, its destructive work is very rapid, and unless prompt and persistent treatment is given serious impairment of vision and, not infrequently, blindness follows. This dangerous infection is contracted through improper care of hands by one suffering from gonorrhœa who is ignorant of its dangers; through carelessness of those dressing such cases, by rubbing the eyes with the hands during or following the dressing before the hands have been thoroughly scrubbed and disinfected; by using a towel or other article previously used by an infected person; through the splattering of discharge into the eye of patient or attendant during the dressing. In the care of such cases it is important to remember to isolate the patient and all utensils, dishes, linen, and other articles used by him; to have a special attendant have charge of such a case that the treatment may be uniform and consistent; to have the attendant wear gown and gloves and protect his eyes by large glasses, which are cleansed and sterilized after each treatment; to keep hands away from face and eyes during treatment and to thoroughly cleanse and disinfect them following each treatment; to promptly and conscientiously give treatments and irrigations ordered, remembering that any pus left in the eye rapidly increases the infection which may involve the cornea and permanently impair the vision. Remember if only one eye is infected to keep the other properly covered and protected at all times so that no infectious material may gain entrance to it. The general procedure in the care and treatment of such cases is the same as for all infected eyes; the above points are emphasized because of the virulence of this infection, the rapidity of its increase when neglected, and the destructive results which follow.

Operations on the eye are usually performed under a local anæsthesia. For this reason the patient should be reassured and instructed as to the importance of remaining quiet and not moving until permission is given by the surgeon. Especial care should be taken to place the patient in a comfortable, unstrained position before the operation starts, and on his return to the ward to see that his position is as comfortable and relaxed as the position required allows. Surgeons' orders in regard to preoperative preparation must be explicitly followed. As in all cases, unless otherwise ordered, the patient should shave and take a full bath the evening previous to the operation. Following an operation

on the eye the surgeon will give definite directions as to postoperative care, especially in cases where the patient must not turn his head or be jarred or in any way help himself, as following an operation for cataract, iridectomy, or similar conditions. Bandages must not be loosened or tightened except by the surgeon's orders, and any misplacement of the bandage or dressings must be reported at once to him. Following an operation on the eye all dressings done and treatment given must be carried out with the most painstaking surgical technique. Impairment or loss of vision is a most grievous affliction.

Most *nursing treatment of ear conditions* consists of irrigations of the external auditory canal. They are termed aural irrigations and should never be given, nor should fluid of any kind be ever introduced into the canal, without a medical officer's authorization. It is necessary to exercise great care in giving aural irrigations and certain precautions should always be taken. Never use a cold solution but have it at the proper temperature and of the required strength. Never use a sharp instrument in the ear, as it might puncture the drum or cause injuries and abrasions through which serious infection might be introduced. When applicators are used for cleaning the auditory canal, or applying ointment or medication, the ends should be adequately padded with absorbent cotton, carefully rolled on and tested before the applicator is introduced within the canal, that there may be no danger of the cotton falling off before the withdrawal of the applicator. Never use force with an instrument or fluid. The irrigator tip should be of rubber, or if a glass tip is used it should be covered with a soft rubber catheter, this only being inserted in the ear. A special aural tip goes into the ear only the required distance; if a rubber catheter is used it should be inserted only just beyond the external orifice, that there may be no injury to the inner surface or to the drum of the ear.

To give an aural irrigation it is necessary, as in all procedures, to assemble all equipment at the bedside or in the dressing room. Where possible, and when permitted, have the patient in a sitting position; otherwise have him lying down with his head turned somewhat to one side and slightly forward. Protect the patient and, where necessary, the bed, with a rubber sheet and towel. Have a kidney basin held under the ear, close to the head and cheek, which are protected from pressure by a pad of absorbent cotton. Cleanse the outer ear and the auditory canal from any accumulation of discharge with an absorbent swab, discarding the swab at once into the waste receptacle. Hang the irrigating can containing the solution about 12 inches above the patient's head. Make certain that the temperature of the solution is correct; if a solution thermometer is not available, run fluid through tubing over the back of the hand until comfortably warm, which at the same time expels all air from the tubing. Grasp the lobe of the ear and draw it gently but firmly upward and backward to straighten out the canal for the inflow of fluid. Direct the stream of the irrigation against the upper surface of the canal, that the fluid may flow gently, without force, against the drum of the ear. The outflow should be continuous during the irrigation and all foreign matter removed by the flow should be noted and its amount and character, together with the time of treatment, recorded on the patient's Clinical Notes. When the irrigation is given to ease pain or to reduce swelling or inflammation the patient should be questioned as to the relief given and his answer recorded; any change in appearance should be noted. Following the irrigation, dry out the canal with a swab and dry off the external ear. Sometimes a soft bit of cotton is placed in the outer opening to catch any remaining solution or discharge, but frequently the ear specialist forbids any closing of the outer

aperture when an ear is discharging, for fear of obstructing free outflow, and thus encouraging an extension of the infection to the inner ear and adjacent parts. Always protect the pillow of a patient having a discharging ear with a rubber sheet or pillowcase and a towel, and provide the patient with plenty of absorbent cotton to hold or place under the ear and to keep the outer surface of the ear clean. See that soiled pieces of gauze, etc., do not accumulate, but that they are at once placed in the waste receptacle provided for them. Following treatment, cleanse and sterilize the equipment and leave in readiness for the next treatment.

Many of the nose and throat conditions requiring nursing treatment are those that follow operations for abscesses, adenoids, deviated nasal septum, nasal polypi, removal of tonsils, etc. The nursing treatment to be given in these and other nose and throat conditions is usually in accordance with specific orders given by the medical officer for each case.

Nasal irritations and pharyngeal douches are frequently ordered in the treatment of nose and throat conditions and instructions concerning each immediately follow.

In administering *nasal irrigations* the stream should be of small caliber and under slight pressure. The patient should lean forward with his chin depressed and mouth open, and should breathe through the mouth. The great danger attending a nasal irrigation is infection of the middle ear, caused by forcing some of the discharge into the Eustachian tube. The following is a list of the articles required for this treatment: 1. A small irrigator with 12 inches or more of rubber tubing attached; 2. Nasal tips attached to the distal end of the rubber tube; 3. A basin in which the used solution may be collected; 4. A towel; 5. A piece of gauze to be used as a handkerchief; and 6. The desired solution (usually physiological salt solution at a temperature of 108° F.). Place the solution in the irrigator, properly connected with the tube and nasal attachment; hang the irrigator in such a position that it will be 2 or 3 inches higher than the patient's nose; allow the solution to flow through the tube until the air contained therein has been expelled, at which time the flow is checked by pressure of the thumb and index finger. Insert the nasal tip in one nostril and permit the solution to flow into that nostril and escape through the one on the opposite side, thus washing out the nasal cavity. If either one or the other side of the nasal cavity is obstructed, the solution should be allowed to flow into that side until the obstruction has been removed, care being taken not to cause too great a pressure. Irrigation should be discontinued immediately if the patient begins to cough or choke.

The chief purposes of a *pharyngeal douche* are to prepare for an operation on the interior of the throat and to act as a cleansing agent in suppurative conditions of the throat. The following appliances are necessary: 1. An irrigator; 2. A piece of rubber tubing 2 to 4 feet long with a clamp attached; 3. A tip (a curved drinking tube often is used); 4. A tongue depressor; 5. A rubber dressing sheet; 6. A dressing towel; 7. A basin; and 8. One quart of physiological salt solution, temperature 100° F., or a specially ordered solution. In administering this treatment it is advisable to cover the rubber sheet with a dressing towel and place it about the patient's neck for the protection of the bed and the patient's clothing. The irrigator should be filled with the required solution and placed in such a position that it is 3 feet above the patient's head, which should be bent forward to prevent the discharge, if present, from being washed down the patient's throat. The basin should be so placed that it collects the used solution which flows from the mouth. The patient's tongue should be

depressed with a tongue depressor and the tip moved gently from side to side in such a manner that the irrigating fluid will reach all parts of the pharynx. Should it be inadvisable to have the patient in a sitting posture, the irrigation may be performed with the patient lying in bed with his head turned to one side.

NURSING CARE OF COMMUNICABLE DISEASES

Communicable diseases are those which may be transmitted from one person to another and are caused by the invasion of the body by living microörganisms. Their entrance into the body is by way of the mouth and nose (respiratory and alimentary tracts), from contaminated food and drink, droplets from breath, infected dishes, linen, and contaminated articles, by bites of infected insects (mosquitoes, body lice, fleas, flies), and by entrance of infective agents through abrasions of the skin and mucous membranes. Tetanus, food infection acquired from the flesh of diseased animals, botulism and diseases such as tularæmia in which an animal serves as a reservoir of infection, are all classified as communicable but are not, under ordinary conditions, transmitted from one person to another.

Often communicable diseases appear in wards other than those assigned to such diseases and it is essential that one should be able to recognize their symptoms and promptly take the necessary steps to provide for the patient's removal to the appropriate ward, and thereby materially lessen the danger of other patients becoming infected.

Communicable diseases are fully described in the section on Hygiene and Sanitation and the general precautionary measures that must be observed in the care of all such diseases, with an outline of the nursing care required in some of those most frequently met with, will now be given.

Those caring for patients with communicable diseases should: 1. Wear a cap and gown, and rubber gloves if necessary, while in the ward or room; 2. Thoroughly scrub their hands and wash their faces, if possible in running water, before leaving the ward or room and before meals, and make a practice of keeping their hands away from their faces; 3. Scrub their hands with soap and water and then immerse them in an antiseptic solution after doing anything for the patient or handling contaminated articles; 4. Wear glasses and a gauze mask over the nose and mouth when caring for patients suffering with diseases in which the causative agent is found in the secretions of the nose and mouth as in diphtheria, meningitis, measles, etc., and be especially careful to avoid the spray from the nose and mouth when the patient is coughing or sneezing.

They should guard their own health by taking sufficient and proper nourishment, avoiding excessive fatigue, taking sufficient exercise in the open air and sunshine, personal cleanliness, and protection by appropriate innoculations. Whenever possible those assigned to the immediate care of patients suffering with a communicable disease should be immune by reason of having had the disease or by having been artificially immunized.

When removed, gowns should be folded so that the inside is kept clean; if hung in the room of the patient the contaminated side should be out and if hung in an adjacent room the contaminated side should be folded in. Gowns should never be worn away from the immediate vicinity of the ward or room.

For medical officers and others not in regular attendance on patients with communicable diseases provision should be made for the cleansing and disinfecting of their hands before leaving the room after completion of their

visit. A basin of hot water, Tincture of Green Soap, a disinfectant, and clean towels should be in readiness for that purpose.

A patient with a communicable disease should be *isolated*, that is, completely separated from others and direct or indirect contact between the patient and others prevented, and both concurrent and terminal disinfection must be conscientiously practiced in his care.

Patients having communicable diseases are generally isolated in special wards or rooms distant from others and with which communication with other departments can be controlled in order to prevent as much as possible any spread of the diseases. Usually such wards or rooms are large, sunny, well ventilated, and completely screened to keep out mosquitoes and flies. There should be no unnecessary furniture, and what furniture there is should be cleaned daily by wiping with a cloth dampened with a disinfectant such as a 1 in 40 solution of phenol.

Concurrent disinfection is the prompt disinfection and disposal of infective material throughout the course of a disease. It must ever be kept in mind, its importance never minimized, and its practice never omitted. All articles used in the examination of a patient and those used by or for him should ordinarily be left in his room and disinfected after use. His bed and other linen should be disinfected or sterilized before being sent to the laundry. Discharges, droplets, and excreta, any and all of which may contain bacteria, must be properly disposed of and disinfected. Gauze handkerchiefs and paper sputum cups should be burned. Excreta should be kept covered until such time as they may be disposed of readily by disinfection or burning.

Terminal disinfection is the definite measures taken to prevent the spread of a communicable disease by infectious material after the termination of the disease. It depends upon the degree of communicability of the disease and the avenues through which infection enters, is discharged, and is carried. Before a patient who has had a communicable disease is discharged or transferred from isolation he should be given a thorough cleansing, including the hair, before he is discharged or transferred from the ward or room. A disinfecting bath, bichloride of mercury 1–10,000, is sometimes ordered. Especial attention should be given to the throat and mouth, and the eyes carefully cleaned. A clean sheet should be arranged for the patient to step on as he leaves the tub or shower, and fresh, clean clothing provided for him to wear when he leaves isolation immediately following his bath. All his baggage and belongings should have been previously sterilized or disinfected and placed in proper storage and safe-keeping. Following the patient's departure the windows of the room should be opened wide to admit plenty of fresh air and sunshine. The walls, furniture, and paintwork should be washed thoroughly with soap and water, followed, when ordered, with a disinfecting solution such as phenol 5 per cent. Mattresses and pillows should be thoroughly aired and sunned for at least 48 hours or sterilized if necessary, and all bed and other linen sterilized immediately. All dishes and utensils should be sterilized by boiling for 20 minutes before returning them to their proper places. The clinical thermometer should be immersed (entirely covered) in a disinfecting solution, e. g., formaldehyde 2 per cent, for at least 30 minutes. In certain instances where deemed advisable, fumigation is used. All attendants should take precautions and practice methods of cleansing and disinfecting their persons and garments to prevent conveyance of infected material from the patient to themselves and to others.

In addition to the discussion of the nursing care of the communicable diseases which follows, the diseases mentioned are arranged in special groups and a brief discription of each disease given.

Diseases characterized by a skin eruption.

Measles.—*Cause:* A filtrable virus *transmitted* by discharges from the mouth and nose; *incubation* period about 8 to 14 days; *symptoms* are coryza, sneezing, cough, nausea, vomiting, chilliness, and fever on the first day from 102° to 104° F. which on the third day gradually drops and then rises with the appearance of the eruption, the temperature dropping by lysis as the rash fades. The *eruption* is seen first on the mucous membranes of the cheeks, prior to its appearance on the skin. On the third or fourth day it appears on the chin or forehead, sides of the neck, face, and the body. It consists of red, elevated spots which run together, forming crescent-shaped blotches. Common complications of measles are: Broncho-pneumonia, laryngitis, otitis media. The *nursing care* consists of darkening the room or shading the eyes, forbidding the patient to read and washing the eyes frequently with boric-acid solution. The nose, mouth, and throat should be kept clean and the room warm and free from drafts. Itching of the skin may be troublesome and may be relieved by cocoa butter rubs.

German measles.—The *cause* is unknown but it is *transmitted* by discharges from the mouth and nose; *incubation* period 14 to 21 days usually about 16 days; *symptoms* are headache, conjunctivitis, pharyngitis, swelling of the glands of the neck, especially those behind and just below the ears, under the occiput, and in the back of the neck, and slight febrile rise. The temperature for a short time may be quite high. In some cases the constitutional symptoms are so slight that the patient hardly seems to be sick. It frequently happens that the first knowledge a patient has of the disease is the appearance of the eruption. The rash and the swollen glands are the two principal diagnostic symptoms. The *eruption* appears within 24 to 48 hours, first on the face, then spreading over the entire body, and usually beginning to fade on the second day. It consists of large, isolated, pinkish macules, resembling the rash of scarlet fever but without the characteristic stippling of the latter disease. The eruption, which usually is altogether out of proportion to the constitutional symptoms, sometimes presents a papular appearance and occasionally consists of small vesicles, which may appear in crops. Pneumonia, nephritis, intestinal disorders, and suppuration of the enlarged glands are complications which may occur. The *nursing care* consists of quietness and rest in bed for at least 1 week, hot or cold applications to the neck, washing the eyes frequently with boric-acid solution, relieving itching of the skin (if present) with cocoa-butter rubs and keeping the nose, mouth, and throat clean.

Scarlet fever.—*Cause*: A hæmolytic streptococcus *transmitted* by discharges from the mouth and nose; *incubation* period is from 2 to 7 days, usually 3 or 4; *symptoms* are sudden onset with nausea, vomiting, chill, sore throat, headache, fever, and rash on second or third day. The temperature is 104° to 105° F. for the first 4 or 5 days, dropping by lysis. The *eruption* or rash appears within 18 to 36 hours, first on the chest and neck, then on the back, face, arms, legs, hands, and feet. It is pin point in appearance, usually scarlet red, very diffuse, and disappears upon pressure. Desquamation takes place in long strips at the expiration of a week or 10 days, and continues from 1 to 7 weeks. Some possible complications are: Otitis media, acute endocarditis, nephritis, and arthritis. Chronic endocarditis and myocarditis, chronic nephritis, blindness, deafness, and paralysis may be sequelæ to this disease. The *nursing care* consists of keeping the room warm and free from drafts, and carefully observing the urine, which should be measured, and the appearance and amount charted.

Smallpox.—*Cause:* A filtrable virus *transmitted* by contact with persons sick with the disease and by articles or persons contaminated by discharges of the sick, including fæces and urine; *incubation* period usually is from 8 to 16 days; *symptoms* appear suddenly and consist of chill, vomiting, and severe headache and intense backache. The temperature is from 103° to 105° F., until the rash appears, at which times it falls. Pustules are formed, usually at the end of the ninth day, associated with a rise of temperature which after several days drops by lysis. The *eruption* appears on the third day on the palms, soles, and the hair line of the forehead, the first stage being characterized by a hard lump under the skin, the second stage by vesicles above the skin, and the third stage by the appearance of pus in the vesicles. Only one stage is present at a time. Some possible complications are septicæmia, pyæmia, myocarditis, nephritis, pharyngitis, abscesses, and cellulitis. The *nursing care* consists of washing the pus from the lesions with a disinfectant, applying oil or vaseline to relieve itching, encasing the hands in cotton gloves, and irrigating the eyes every two hours. Anyone caring for a smallpox case should have been vaccinated recently.

Chicken pox.—*Cause:* A filtrable virus *transmitted* directly from person to person and indirectly through articles freshly soiled by discharges from an infected person; *incubation* period is from 2 to 3 weeks; *symptoms* are chilliness, mild headache, and a temperature of 100° to 102° F., for the first two or three days, at the end of which time it returns to normal. The *eruption* appears within 24 hours in crops on the trunk, back, and chest, all stages being present at the same time, new crops coming out before the old ones have disappeared. The skin lesions are very itchy. The *nursing care* consists of sponging and oiling the skin daily, and using cotton gloves, if necessary.

Diseases transmitted by discharges from the intestinal tract.

Typhoid fever.—*Cause:* The *Eberthella typhosa* (*Bacillus typhosus*) *transmitted* by direct or indirect contact with a source of infection; *incubation* period is from 3 to 38 days, usually 7 to 14; *symptoms* are, at the onset, headache, nausea, pain in back, legs, and abdomen, loss of appetite, coated tongue, epistaxis, diarrhœa, and frequently bronchitis; later the spleen becomes enlarged, the Widal reaction becomes positive, stools become liquid yellow (pea-soup appearance), or the patient may be constipated. The temperature during the first week rises a degree or degree and a half higher each evening and drops slightly each morning. During the second week it remains continuously high (103° to 104° F.), with a very slight morning remission, and during the third week the remissions are more marked; in favorable cases the decline is gradual and in mild cases the temperature reaches normal at the end of the third week. The majority of normal cases end in the fourth week of the disease. The pulse varies from 80 to 100, is dicrotic and slow in proportion to fever. Hæmorrhage and perforation of the intestine are indicated by a sudden, rapid, and weak pulse, associated with marked rapid fall of temperature. The tongue is coated white at first, and later becomes very dry and brown or black in the center. The approach of convalescence is indicated when the tongue begins to moisten and become clear around the edges. The mental condition is usually dull and stupid and frequently is accompanied by delirium. A continued low, muttering delirium, with picking at the bedclothes, is an unfavorable symptom. A typhoid-fever patient never should be left unattended. After 7 to 10 days small, rose-colored spots, which disappear upon pressure, appear on the abdomen, the lower part of the chest, and the back, remain for 2 to 3 days and fade, leaving a brownish stain for a time. Successive crops of "rose spots" form until the

middle of the third week. Some common complications are tympanites, hæmorrhage from the intestine, perforation of the intestine, and dilation of the heart. Endocarditis, empyæma, periostitis, meningitis, pneumonia, phlebitis, and thrombosis may be the sequelæ. The *nursing care* consists of carefully watching the patient's position, which should be recumbent and changed frequently, and support being afforded with pillows. All exertion on the part of the patient must be avoided, and he should have absolute rest. The mouth should be kept clean, guarding against reinfection; the prescribed diet should be strictly adhered to and plenty of water should be given. Daily enemata usually are prescribed if necessary. No cathartics should be given, and the buttocks should be washed after each stool. Special care should be observed to prevent bedsores.

Bacillary dysentery.—*Cause:* The *Shigella dysenteriæ* and *Shigella paradysenteriæ (Bacillus flexneri)*, *transmitted* by infected foods, contaminated water, hand-to-mouth transfer of infected material, by flies, and by objects soiled with discharges from infected persons or carriers; *incubation* period is 2 to 7 days. This disease is highly infectious, is characterzed by a sudden onset and its *symptoms* are frequent small stools, containing blood, mucus, pus, and very little fæces, and accompanied by tenesmus, with pain and tenderness over the colon. In severe cases the temperature is high, there is great prostration, and excessive toxæmia. Death frequently results within a few days. Some of the common complications are emaciation and anæmia. The *nursing care* consists of maintaining plenty of fresh air, quiet, and cleanliness. Stools should be carefully observed and charted. Rectal irrigations frequently are prescribed, and in administering them great care and caution are necessary.

Cholera.—*Cause:* The *Vibrio comma (Spirillum choleræ)*, *transmitted* by food and water polluted by infectious organisms, by contact with infected persons, carriers, or articles freshly soiled by their discharges, and by flies; *incubation* period is from 1 to 5 days, usually 3; *symptoms* headache, malaise, diarrhœa, and colic. During the later stage or stage of collapse, excessive vomiting, purging, high temperature, cold and clammy, shrunken and livid skin, rapid emaciation, intense thirst, severe muscular cramps, diminished secretion of urine, and rice-water stools (water and salts from the blood, and epithelium from the intestinal walls) are present. An increased temperature with a warm feeling of the body indicates the turning point, and recovery usually results. Failure of the heart action is the most common complication. The *nursing care* consists of isolation, absolute quiet, the application of external heat, and the administration of physiological salt solution by hypodermoclysis.

Diseases transmitted by insects and other arthropods.

Malaria.—This disease results from invasion of the red-blood cells of man by one of at least three types of the genus *Plasmodium*, class *Sporozoa*, division *Protozoa*, of the animal kingdom. The three types are the *Plasmodium vivax*, the *cause* of benign tertian malaria, the *Plasmodium falciparum*, the *cause* of malignant tertian or æstivo-autumnal malaria, and the *Plasmodium malariæ*, the *cause* of quartan malaria. The only known means by which malarial parasites are *transmitted* is by the bite of an infected female Anopheles mosquito which usually bites at dusk or at night. *Symptoms* are chills and fever.

During and after the chill the patient usually has a headache, is nauseated, the pulse is frequent and full, the temperature is very high (occasionally 107° F.), and is accompanied by profuse sweating. Severe cases of malaria may show typhoidal symptoms, while mild cases usually feel comparatively well between chills, the temperature, pulse, and respiration being normal. Some of the common complications are anæmia, congestion of the liver and kidneys, and

bloody urine. The *nursing care* consists of noting and recording all chills, their duration, time of starting and ending, and their severity, varying from a slight chilly sensation to shaking of the entire bed. Temperature, pulse, and respiration should be taken every hour after a chill until they return to the previous temperature, pulse, and respiration. During a chill external heat should be applied and the patient surrounded with hot-water bottles and kept in bed. Plenty of easily digested, nutritious food should be given and the bowel and kidneys kept active. The prevention of malaria is taken up in the section on Hygiene and Sanitation.

Yellow fever.—*Cause:* A filtrable virus *transmitted* by the bite of infected Ædes ægypti and allied species of mosquitoes; *incubation* period is 3 to 6 days, rarely longer; *symptoms* characterized by sudden onset, a chill, muscular pain, especially in the legs and back, jaundice of the skin and conjunctivæ, and vomiting (sometimes black vomitus or digested blood). The eyes become watery, glazed, and sunken; the temperature reaches 102° to 103° F. for 2, 3, or 4 days, when it drops to normal. At the end of 24 hours it rises to 102° F., then falls by crisis or lysis. The pulse rate is first 90 to 115 and later comparatively slow. Some of the common complications are suppression of urine and hæmorrhage from any part of the body. The *nursing care* consists of keeping the patient absolutely quiet. Hot applications, counterirritants, and light massage should be applied for muscular pain. All urine should be measured, its appearance noted and charted. The patient's bed should be covered with cotton netting.

Typhus fever.—This disease, the *cause* of which is *Rickettsia prowazeki, Rickettsia quintana,* and, provisionally, *Rickettsia mooseri,* occurs in a classical, severe, epidemic form *transmitted* from man to man by the bite of the body louse, and in a mild, sporadic form *transmitted* from rat to rat or to man by scratching or rubbing the fæces of fleas into the tiny wounds made in the skin by the biting of the fleas, the infection not being introduced directly by bite; the *incubation* period is 5 to 20 days, most often 12 days; and the *symptoms* are variable onset, often being sudden, chills, headache, fever, general pains, toxæmia, and delirium. The temperature is high during the first week, with a marked remission in the morning during the second week, and at the end of 13 to 14 days returns by rapid lysis to normal. A macular eruption appears on the fourth to sixth day as elevated rose spots or patches which later assume a dusky hue, lose elevation, and appear as ecchymotic areas under the epidermis. The *nursing care* consists of maintaining an abundant supply of pure, fresh air and the usual general fever nursing.

Diseases which may result from an abrasion of the skin or mucous membrane.

Tetanus.—The *cause* of this disease is the *Clostridium tetani (Bacillus tetani), transmitted* by direct infection of a wound; *incubation* period is commonly 4 days to 3 weeks; *symptoms* are rigidity of muscles, beginning with the jaws and neck, and progressing until all except the arms are involved. Convulsions are caused by the slightest stimuli and vary in severity, sometimes reaching the extent that the body becomes arched so that the head and heels only touch the bed. The temperature varies from 103° to 105° F., and the pulse rate is about 110. The *nursing care* consists of maintaining absolute quiet, keeping the room dark, and general nursing care and prophylactic measures. It is frequently necessary to resort to nasal or rectal feedings.

Septicæmia.—*Caused* by pus-forming organisms *transmitted* directly to the blood stream; *incubation* period is from 2 hours to 2 or 3 days; *symptoms* are chills, temperature of 102° to 105° F., nausea, headache, anorexia, and all the

febrile symptoms. Cases of this disease often become typhoidal in type with or without delirium, the skin becoming cold, the body freely perspiring, marked cyanosis being present, and the face being pinched and drawn. Pyæmia is a common complication. The *nursing care* consists of maintaining plenty of fresh air, an abundance of nutritious food, and careful general nursing.

Erysipelas.—*Caused* by the *Streptococcus erysipelatis*, a type of the *Streptococcus pyogenes* (*Streptococcus hæmolyticus*); incubation period is from 24 to 72 hours; *symptoms* are sudden onset with chill, nausea and vomiting, high temperature, and appearance of localized inflammation of the skin. The area of skin involved is red, swollen, and sharply limited, and sometimes is accompanied by severe pain. The *nursing care* consists of isolation, the administration of plenty of fluids, and rigid precautions against transmitting the infection to surgical cases. It is imperative to use all prophylactic measures.

Diseases of the respiratory tract.

Influenza.—The primary *cause* is a filtrable virus, often associated with various types of other bacteria, *transmitted* by discharges from the mouth and nose; *incubation* period is from 2 to 4 days; *symptoms* are sudden onset with slight chill, intense aching of muscles (legs and back), coryza, frequently sore throat, and increase in temperature in mild cases to 100° to 102° F., in severe cases to 103° to 104° F., dropping by lysis to normal. Otitis media, sinusitis, bronchitis, pneumonia, and myocarditis are common complications. The *nursing care* consists of keeping the room warm and free from drafts and general nursing.

Pneumonia, acute lobar.—*Caused* by infection of the lungs with various pathogenic bacteria such as the *Diplococcus pneumoniæ* (*Pneumococcus of Fraenkel*), *Klebsiella pneumoniæ* (*Friedlander's bacillus*) and occasionally the *Streptococcus hæmolyticus* and the *Hæmophilus influenzæ* (*Bacillus influenzæ*), *transmitted* by direct contact with infected persons or carriers, or with articles freshly soiled with the discharges of the nose and throat of such persons, and possibly from infected dust of rooms occupied by infected persons; *incubation* period usually is from 1 to 3 days but is not well determined; *symptoms* are sudden onset with chill, severe pain in chest, fever, and usually cough and dyspnœa. The temperature rises to 104° or 105° F., and remains high for from 3 to 9 days, at which time it falls to normal or below in a few hours (crisis) or more slowly (lysis); the respirations are shallow, rapid (up to 60), and labored, and the pulse is full and bounding (96 to 120 or 140). During the first stage of the disease the sputum is a frothy, serous fluid mixed with mucus, and streaked with blood; during the second stage it becomes prune juice or brownish red in color, due to the presence of blood; and during the third stage it is abundant, shows evidence of less blood, which gradually disappears, the sputum gradually becoming less in quantity, until it returns to normal. Cyanosis, œdema of lungs, tympanites, circulatory failure, and pleurisy are common complications. Empyæma, abscess of the lung, and gangrene of the lung may be sequelæ. The *nursing care* consists of limiting all movements of the patient which require exertion, etc. Tenacious or sticky sputum should be carefully wiped from the lips with small pieces of gauze and placed in a paper bag to be burned later. The patient must be encouraged not to talk too much. Visitors should not be permitted except by the medical officer's permission. Unfavorable symptoms, especially delirium, should be watched for. Maintain plenty of fresh air, keep the patient warm, and avoid drafts. A rectal tube having its free end in a pus basin may be inserted and hot fomentations applied to the abdomen to relieve discomfort in tympanites. The patient should

not be permitted to sit up during convalenscence until orders to that effect are issued by the medical officer in charge of the case.

Tuberculosis, pulmonary.—*Cause*: The *Mycobacterium tuberculosis* (*hominis*) (*Bacillus tuberculosis*), usually *transmitted* through discharges of the respiratory tract and occasionally through those of the digestive tract, by direct or indirect contact with infected persons, by means of coughing, sneezing, or other droplet infection, by kissing, by the use of contaminated eating and drinking utensils, and possibly by contaminated flies and dust; *incubation* period is variable; *symptoms* are loss of appetite, loss of weight, a short hacking cough with the production of more or less sputum, a moderate increase of temperature in the afternoon, a hectic flush, especially in the afternoon, and a soft and rapid pulse. Later in the disease there are usually emaciation, progressive weakness, and night sweats. The *nursing care* consists of keeping the patient out of doors and dressed warmly, giving an abundance of nutritious foods, and general nursing care. Sputum cups should be kept covered and later disinfected and burned. Separate eating and drinking utensils should be provided for a tuberculous patient and sterilized after use. Bed and other linen should be sterilized before being sent to the laundry, and all handkerchiefs, cloths or other articles soiled with sputum should be disposed of by burning.

Tubercle bacilli of the type found in cattle and, rarely, of the type found in birds, have been found in pulmonary lesions in man.

Diphtheria.—This disease occurs in the upper air passages and is *caused* by the *Corynebacterium diphtheriæ* (*Bacillus diphtheriæ*); is *transmitted* directly by personal contact, indirectly by articles freshly soiled with discharges, or through infected milk or milk products; the *incubation* period is usually 2 to 5 days, occasionally longer; and the symptoms are general malaise, swelling of the glands of the neck, and soreness of the throat. At first the throat is red and slightly swollen but by the end of the first day a pale, gray membrane appears on the tonsils and may extend to the pillars, the uvula, pharynx, and soft palate. This membrane is removed with difficulty and leaves a bleeding surface. The temperature is comparatively low, seldom rising above 103° F., lasts from 7 to 10 days, and falls by lysis. The pulse is rapid and in severe cases, weak, and irregular. Cardiac weakness is indicated when the pulse rate falls below 60, or increases above 120. The common complications are heart failure, acute nephritis, broncho-pneumonia, paralysis, especially of the muscles of the eyes, the pharynx, and the vagus nerve. The *nursing care* consists of spraying and irrigating the throat, giving plenty of nourishment and water, watching for regurgitation of food and water, and preventing all exertion and excitement. The patient should not be allowed to sit up too soon during convalescence, because of the danger of overtaxing the heart. Preventive measures are taken up in the section on Hygiene and Sanitation.

Before concluding the nursing of communicable diseases it is necessary to give the general care required for patients suffering with inflammation of the meninges of the brain or spinal cord.

Meningitis.—*Cause:* The *Neisseria intracellularis* (*Diplococcus intracellularis meningitidis*, or *Meningococcus*), *transmitted* by direct contact with infected persons and carriers and indirectly by contact with articles freshly soiled with discharges from the mouth and nose of such persons; *incubation* period is 2 to 10 days, commonly 7; *symptoms* are sudden onset, chill, or convulsion, intense headache, projectile vomiting, photophobia, and strabismus. The temperature runs an irregular course; the muscles of the neck become rigid, the head is retracted, attempts to extend the thigh and leg meet with resistance,

and the skin and muscles become very sensitive. Pneumonia, pleurisy, endocarditis, pericarditis, and otitis media are the common complications. Deafness, blindness, local or general paralysis, and mental derangement may be the sequelæ. The *nursing care* consists of maintaining absolute quiet; keeping the room cool and dark and at a temperature of 65° F., the practice of general prophylactic measures, and nasal feedings, if necessary.

NURSING CARE OF THE DELIRIOUS PATIENT.

In the condition known as delirium there is mental excitement and confusion which is usually accompanied by false sense-perception (hallucination) of objects or phenomena having no actual existence, as hearing voices or seeing imaginary persons, or a false interpretation by the mind (illusion) of actual objects, as mistaking a piece of furniture for an animal. Delirium usually occurs in a *low muttering* form or a *wild* or *violent and noisy* form and among its causes may be mentioned toxæmia, anæmia, uræmia, the use of drugs, exhaustion from illness and shock, and acute or chronic alcoholism.

The characteristics of the low muttering type are constant or occasional disconnected and irrational speech, restless impulses, disturbing dreams, attacks of weeping or excitement, impaired mental and muscular power, involuntary urination and defæcation, and, frequently, plucking at the bed-clothes. When restlessness is present the patient continually tries to get out of bed and not infrequently attempts to escape. This type of delirium may be present in all the acute infectious fevers and in typhoid fever is almost invariably present.

In the violent and noisy type, usually associated with toxic conditions due to uræmia, alcoholism, and poisoning by drugs, wild, maniacal excitement occurs.

When caused by alcohol it is termed delirium tremens. The patient is noisy or quiet, violent or calm, at different times, but always is difficult to control, is usually insensible to his surroundings, his speech is rapid and incoherent or irrelevant, eyes open and staring with pupils usually dilated, and face flushed. In this type of delirium homicidal mania may suddenly develop.

In the *nursing care* of a delirious patient remember never to leave him alone; even when the symptoms appear mild he requires constant watching. Medicines should never be given in pill or powder form and his food or nourishment should be given regularly and slowly. If urination is not involuntary be sure that it takes place regularly, and if it does not occur at least once in every 8 hours promptly report the fact to the proper authority. An accurate record of the patient's condition should be kept and other patients prevented from coming near him. Nothing with which the patient might injure himself or others should be where he might get it. Always have the means for quickly restraining a delirious patient near at hand.

Restraint appliances consist of strait-jackets of various types, leather or canvas wristlets or anklets (commonly called cuffs) and other mechanical devices which are easily adjusted, are usually available for patients whose condition requires their use. For mild cases bed-boards, sheets and bandages may be used. Restraint appliances should be used only when absolutely necessary as they tend to antagonize and irritate a patient. In using restraint appliances care should be taken to insure that there is no interference with the patient's circulation or respiration, and therefore a patient should never be restrained across the chest. Knots should never be within reach of the patient's fingers or teeth and never where they might cause pressure or discomfort to him. When cuff restraint is used the cuffs should be applied on opposite sides for if applied to the same side the patient may easily fall out of bed and severely

injure himself. All restraints should be applied in such a way that they are neither too tight nor too loose.

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Section 2.—WARD MANAGEMENT

Responsibility for the successful management of a ward rests primarily upon the person in charge of the ward who, to properly discharge the duties comprising that responsibility, must possess the essential quality of executive ability.

In addition to supervising the nursing care of patients, as described in the preceding section, it is the duty of the person in charge of a ward to see that work in the ward is carried on without friction, to direct the cleaning or housekeeping of the ward and adjacent rooms, to make sure that orders for the care and treatment of patients are fulfilled, to preserve in good condition all instruments, equipment, or other property charged to the ward, to keep an adequate stock of supplies on hand and prevent waste in their use, and to give instruction in nursing procedures to those requiring it.

In naval hospitals the executive officer usually has general supervision of all patients and he therefore has general supervision of all wards and, as a rule, inspects them daily as to cleanliness, good order, and care of patients. Each ward is under the direct supervision of a medical officer, termed the ward medical officer, who is responsible to the executive officer and his chief of service. The chief nurse in a hospital has general charge of the nursing in all wards, of their maintenance, and of the members of the Nurse Corps, U. S. Navy, who usually are in direct charge of all medical and surgical wards. Wards in which patients with venereal or genito-urinary diseases are domiciled and treated are in direct charge of senior petty officers of the Hospital Corps. Nurses and hospital corpsmen in charge of wards are responsible for the care and nursing of the patients and the management of the ward as outlined in the preceding paragraph. In their absence the senior hospital corpsman assumes charge of the ward. The executive officer details hospital corpsmen to duty in all wards and when so assigned they are under the supervision of the nurse or hospital corpsman in charge, and under their direction they administer medicines, give treatments, do dressings, give patients the necessary nursing care, and attend to the cleaning of the ward.

MANAGEMENT AND GENERAL SUPERVISION OF WARDS

The management of a ward in a hospital or a hospital ship and of the sick bay on board ships requires a well-arranged schedule of work, a regular and systematic routine for cleaning, and the proper assignment of the personnel to definite nursing and other duties.

A schedule of work in either a ward or a sick bay must first take into consideration the necessity of allowing sufficient time for those on duty in a ward or sick bay to dress, make up their beds, and attend to their personal toilets before reporting for duty. It is essential that a schedule provide for a dis-

tribution of work according to the amount of work, the kind of patients cared for, the arrangement of the ward and adjacent rooms, and the number of persons assigned to the ward for duty. The nursing care (bed-making, bathing, medication, etc.) of the patients in a ward should be divided so that, as far as practicable, one attendant continually looks after certain patients who, to save time and for greater convenience, should be grouped together as closely as possible.

In arranging a schedule of work the more responsible duties should be assigned to those having the most experience and the simplest duties to those of least experience. For the training, instruction, and development of nursing proficiency of the latter it is advisable to rotate their assignments every week or 10 days so that the performance of duties does not become monotonous and experience in all may be gained. When a new hospital corpsman reports to a ward the nurse or hospital corpsman in charge should acquaint themselves with the amount of previous experience he has had and arrange his assignments to duty accordingly. If just reporting from one of the Hospital Corps Schools they should teach him the actual bed-side care of the sick, how to give treatments and medications, and all phases of ward duty. They should continue to instruct, supervise, and observe the work of the new man until certain that he understands exactly what is expected of him and can be depended upon to do it correctly. To help a new man attain that degree of proficiency he should be detailed as often as possible to assist experienced men in the care of the sick. Actual contact with illness deepens the sense of responsibility, quickens the powers of observation, resource, and helpfulness, and ends a careless, frivolous, or flippant attitude more quickly than any other means.

In the management of wards it is essential that those in charge endeavor at all times to assign personnel to the various ward duties and to so arrange the ward work that there is the least possible amount of friction. This greatly helps in maintaining the spirit of cooperation so necessary between medical officers, nurses, hospital corpsmen, and patients, if a ward is to function efficiently, and results in the cheerful atmosphere in the ward that aids in the recovery of the sick.

Daily ward duties.

In the morning, before breakfast is served, the hospital corpsman on night duty in a ward should see that all bed patients have their faces and hands washed, their mouths cleansed, and teeth brushed, and that all other patients do the same for themselves. The temperature, pulse, and respiration of all patients should be taken and recorded in a book kept for that purpose; all medications and treatments ordered to be given before breakfast should be given; all specimens for examination should be collected and taken or sent to the laboratory; and all preoperative routine carried out before the night man goes off duty.

Breakfast is served by the hospital corpsmen on day duty and they are responsible for patients receiving the right diets. Patients too ill to feed themselves must be fed by hospital corpsmen or by patients who can assist in this way. In hospitals where the food is not served from regular food carts under the supervision of a dietician, the men on duty in the ward diet kitchen should report in ample time to have steam turned on the steam tables and trays prepared so the serving of breakfast will not be delayed. It is most important that the breakfast be served and all trays and dishes collected and returned to their proper places as promptly as possible for if breakfast is late the whole day's work is delayed.

If food on any tray remains untouched it is necessary to determine the reason; it may be that the patient needed assistance in order to eat, or that he had lost his appetite, or for some other reason did not desire food. Whatever the cause, a report should be made to the medical officer.

After breakfast beds should be made up, bed baths given, and the ward aired, swept, and dusted, and then put in readiness for morning sick call at 9:00 a. m. Beds, chairs, and bedside lockers should be aligned; the latter should be washed and all trash disposed of. Only toilet articles and clothing actually needed should be allowed in bedside lockers and they should be kept neatly and in good order. Under no circumstances should food stuffs or medicines be kept in bedside lockers.

As soon as nurses or hospital corpsmen report in the morning they should visit all the seriously and critically ill patients so that they may acquaint the medical officer of their condition when he arrives for sick call. All charts should be up-to-date and, with all clinical notes and all X-ray, laboratory, and special reports attached, should be placed on the foot of the patient's bed or in a convenient place for the medical officer to see.

During sick call everyone should be as quiet as possible and all convalescent patients who are able should stand by their beds unless excused by the ward medical officer.

When making sick call with the ward medical officer the nurse or hospital corpsman in charge of the ward carries the ward order book and enters in it in ink all orders of the medical officer, which he afterward reads and signs. All orders for narcotics should be signed when the order is given. Another hospital corpsman carries towels, tongue depressors, flash-light, stethoscope, etc., for the medical officer's use in making sick call. Hospital corpsmen who are not making sick call should continue with their work, being careful not to cause undue noise or commotion.

The following routine forms should be ready at sick call for the signature of the ward medical officer: Liberty list, duty cards, transfer slips, requests for leave or special liberty, etc., drug book, and diet sheet. The drugs needed should be entered in the drug book and after being signed taken to the pharmacy where the drugs will be issued. After the diet sheet has been signed it should be sent to the chief nurse. Before 9:30 a.m., daily, the ward report, which is a special printed form giving the census of the previous day and the census to date, the number of admissions, discharges, deaths, and absentees, should be made out in duplicate, one copy being sent to the personnel office, the other to the office of the chief nurse. It is very important that the nurse or hospital corpsman in charge of the ward have all forms ready for the ward medical officer's signature immediately after sick call. As early as convenient other forms, such as laundry slip in duplicate for exchange of linen, daily blanket count, request for repairs, etc., should be prepared. Expendable and nonexpendable supplies are ordered in separate books once each week. These forms must be signed by the ward medical officer, and then sent to the chief nurse, who forwards them to the executive officer.

After sick call is over the order "carry on" is given, charts are collected and returned to their proper place, uncompleted work in the ward finished, treatments and medicines administered, dressings done, slips taken to their respective offices, and the ward made ready for the executive officer's inspection. All supplies for the day should be obtained between the hours of 10 and 12 and drug baskets gotten from the pharmacy before noon. Attention should be given to medicines, temperatures, and diets between 11 o'clock and noon. After dinner the patients should be allowed to rest and the hospital corpsmen should

police the wards and carry on the necessary work of the ward. A hospital corpsman under no circumstances should leave the ward without permission or proper relief. On visiting days he should see that visitors do not sit or recline on the beds, provide chairs for visitors, and when visiting hour is over, see that they leave the ward. If visitors have not heard the word passed that visiting hours have ended, the hospital corpsman should politely inform them that it is time for them to go. The evening meal then is served, and not sooner than one hour afterwards evening toilets should be given. Evening sick call is held some time after 7 o'clock, and should be followed by the evening treatments, medicines, and dressings. All patients are mustered, any absentees reported to the officer of the day, and all ward lights, except night lights, put out at taps. The wards, heads, bathrooms, diet kitchen, and offices should be left in a clean condition by the day force. In refrigerators that are not electric there should be sufficient ice for the night as well as enough supplies, such as milk, fruit, eggs, and broth, for the fluid diets, and, when necessary, eggs for the morning breakfasts.

Ward cleaning.

The cleanliness of a ward is of great importance, for dust and dirt favor the growth of bacteria. The procedures necessary in keeping a ward clean are largely of a housekeeping character and ward cleaning might well be termed ward housekeeping. Such procedures should disturb the comfort of the patients as little as possible and must not interfere with their care and treatment if it can be avoided. The work required in ward cleaning, or housekeeping, should be divided as equitably as possible among the duty personnel, that to be done by the nurse or hospital corpsman in charge naturally being considerable less because they must supervise all such work and on account of their other responsibilities. Each hospital corpsman assigned a detail must know exactly what is expected of him and that he is responsible for that detail. Patients who are able may be assigned to help on such details.

It is advisable that each day of the week be set aside for some special cleaning, such as walls, windows, and wood work on one day, beds, bed-side lockers, and metal furniture on another, cleaning and polishing decks on another, etc. When certain special cleaning is done on a certain day of the week there is not so much left for "general field day" and it will be found that wards will almost always be in good order.

Each day's special cleaning should be started as soon as possible on the day assigned it, the routine cleaning going on as usual in the meantime so that by 10:00 a.m. the ward and its service rooms are ready for inspection by the chief nurse and by the executive officer who may inspect at any time.

Everything in a ward, beds, lockers, chairs, desks, windows, radiators, electric light fixtures, doors, woodwork and paintwork should be dusted daily. On the death of a patient the springs of a bed should be whisked with a disinfectant solution and the bed washed with hot water and soap.

In dusting, a damp (not wet) duster should be used, a basin of clean water should be at hand in which to rinse the duster frequently. It is impossible to clean anything with dirty water or a dirty duster. The habit of removing dust with a firm stroke should be formed, as it is a waste of time and energy to move the duster back and forth on a surface. Dust should be removed from cracks and crevices (those too small for the duster to enter may be cleaned with the point of a wooden toothpick), and when dusting beds, the bars which are not exposed should not be forgotten. When cleaning the medicine cabinet, remove only a few bottles at a time (if called away they will not have to be

left out of place). If dusting is done daily and systematically, everything will be ready for the commanding officer's inspection without any extra effort. Dusters always should be washed after use and not put away unclean. Polished furniture should be dusted with a dry duster or one that has been slightly oiled.

The walls of a ward should be swept down once a week with a long-handled broom and, if possible, washed once a month.

The cleaning of floors depends upon the material of which they are made. They should be swept as often as necessary, at least three times a day, and care taken that no more dust is raised during the sweeping than is necessary. Stone and unpolished wooden floors should be scrubbed occasionally with a scrubbing brush, hot water, and soap powder. The water should be changed frequently. Dirty water will not clean anything. After washing, floors should be thoroughly dried and hardwood floors should be waxed and polished once each week.

Copper, brass, and nickel should be cleaned frequently with metal polish. Sand soap should not be used for glass or metal, as it may scratch the surface. Porcelain tubs and sinks are cleaned best with hot water and the special cleansing materials provided for that purpose.

The refrigerator and water cooler should be cleaned as early in the morning as possible so that they may be ready for the daily supply of ice, fruit, etc. The water cooler should be taken apart and washed thoroughly inside and out with hot soap and water, scalded well, and rinsed with cold water.

When cleaning the refrigerator, all foods, drinks, bottles, etc., should be removed, its shelves should be taken out, thoroughly washed and scalded, placed in the open air and sunshine while the ice compartment and the inside and outside casings are being cleaned. The drain pipe and drain pan (when one is used) should receive special attention, be washed with hot soapy water and scalded; the pipe should be taken apart and each section freed from all residue and slimy deposit. Scalding water should be run through this, and the drip pan well rinsed with the same. Drain pans should be emptied three times a day. Doors of the refrigerator should be kept closed, except when cleaning or putting in or taking out supplies. The shelves and all containers should be well dried before being returned to their places, and any left-over supplies used at once or returned to the commissary department. Accumulation of supplies should be guarded against and only those ordered which are actually required.

Tables and dish cabinets and all of their drawers and shelves should be scrubbed and aired daily. No paper covers or linings should be used for these as they form hiding places for roaches and food crumbs. Grease or hardened food particles on trays, silver dishes, or any kitchen utensils are evidences of neglect and carelessness, and should not be tolerated. Coffee or tea grounds should never be thrown in the sink nor should oil or grease in any quantity be poured there. A clogged drain pipe causes much unnecessary labor and waste of valuable time.

All dishes and silver should be thoroughly washed and sterilized after use. In most hospitals electric dish washers are provided, and readily accomplish this. When a mechanical dish washer is not provided, dishes used by a patient isolated in a general ward should be given special attention, reserved for his special use, and kept on a marked tray. They should be sterilized by boiling in a large pan, or other vessel, and the hospital corpsman handling them before they are sterilized should carefully wash and disinfect his hands before handling other things.

Utensils such as bedpans, urinals,, irrigating cans, etc., should be scrubbed daily with hot water, soap, and a brush, and kept clean at all times.

Rubber sheets and other rubber articles such as air cushions, hot-water bottles, ice-bags, etc., are cleaned best with warm (not hot) water and soap; after washing they should be rinsed well as soap tends to destroy rubber. They should then be wiped with a disinfectant solution and hung up in a cool place to dry. Rubber sheets and operating pads should be rolled instead of folded before being stowed away, and under no circumstances should they be put away until thoroughly dried. Remember that heat, acids, and fats destroy rubber.

The brooms, deck-swabs, dustpans, dust cloths, and materials used in cleaning should always be stowed in the spaces provided for them when not in use. Before stowing deck-swabs they should be thoroughly cleaned by washing in warm water and soap. Where fresh water is available ordinary soap or soap powder may be used but salt-water soap must be used with salt water. Remember to use hot water to remove dirt and the addition of a small amount of sodium carbonate (washing soda) or ammonia will soften the water and help to remove grease. Lye never should be used without a definite order and special reason as it is dangerous to handle and is destructive to materials. When lye is used great care must be taken to dissolve it first in water, and to open the can over a hopper or on a cement or stone deck to prevent the powder from destroying and staining woodwork, paint, varnish, etc. Be sure to clean all corners and crevices, moving furniture when necessary in order to clean behind it. In sweeping use long smooth strokes so that no unnecessary dust is raised to scatter through the ward. All metal work should be kept clean, bright, and shining by the use of the agents best adapted to each metal accompanied by vigorous rubbing. Porcelain tubs and sinks should be cleaned with kerosene, soap and water, scouring powder, or other effective cleaning material in routine use. Never use a strong acid or alkali on porcelain, tile, or marble, as it destroys the finish and roughens the surface, causing it to readily accumulate grime and microörganisms. Never allow any refuse to be thrown down the toilets, hoppers, etc. Toilet paper is the only material of this type that is soluble, and made purposely for use in these places. Waste receptacles are provided for all other débris and should be used. Sputum cups and other similar containers of infectious material should be carefully covered and carried directly to the incinerator, never thrown loosely into trash receptacles.

Linen used for patients suffering with communicable diseases should be placed in a bag kept for this purpose and sterilized or disinfected before being taken to the laundry. Most hospitals are equipped with a large steam sterilizer for this purpose, but when this means is not available the linen is placed in some disinfecting solution or exposed to the direct sunshine and fresh air for an hour or more, turning at least once so that the sun's rays may reach its entire surface.

"General field day" is a term used to designate the general, final cleaning of wards, service rooms, furniture, etc. in preparation for inspection by the commanding officer on the day following. On the morning of general field day the ward need not be in the usual order for sick call, but patients must have their usual care, and their records must be in readiness. On general inspection by the commanding officer the entire ward should be in readiness by 10:00 a. m. A preliminary inspection should be made by the ward medical officer and the ward nurse to assure the personal cleanliness and comfort of the patients and the order and cleanliness of the ward and its service rooms.

For general inspection by the commanding officer all charts and accompanying records, order books, narcotic books, and admission book should be up-to-date and in a convenient place for examination. All lockers should be clean and all doors opened except medicine, narcotic, and linen lockers, which doors are opened in the presence of the commanding officer and closed immediately afterward. Bed-side lockers and table and desk drawers should be open. All ambulatory patients should be in the uniform of the day and by their beds at this inspection, during which there should be absolute quiet and no smoking, card playing, or reading allowed. The ward medical officer, nurse or hospital corpsman in charge of the ward, and another hospital corpsman with a flashlight and a towel dampened at one end should meet the inspecting party at the ward entrance, take places beside the commanding officer and remain there throughout the inspection in order that they can answer his questions and record any suggestions he may offer. A hospital corpsman should precede the inspecting party to open doors and turn on lights. All orders and suggestions given during the inspection must receive prompt and careful attention.

Ward property and linen.

The utmost attention must be given to preserving in good condition all instruments, equipment, linen, or other property in a ward. All nurses and hospital corpsmen should take a personal interest in the upkeep of Government property, should see that it is not abused, and those in charge of wards should be especially careful to see that necessary repairs are given prompt attention. A record of the property with which a ward is charged should be kept and the property inventoried once a month to determine if there has been any loss. After making the inventory the nurse or hospital corpsman in charge of a ward prepares and signs a statement concerning the ward property which is submitted to the executive officer for approval or such other action as may be necessary. If, on taking inventory, property is found to be missing, efforts to locate it should be made and if it cannot be found then responsibility for its loss should be determined if possible, and the loss and the responsibility therefor reported to the executive officer. Property may not be transferred without prior approval of the executive officer.

Linen should receive special attention and a general inventory should be taken weekly. Soiled linen should be counted before going to the laundry for exchange for clean linen and the clean linen counted before leaving the linen room, the exchange being made piece by piece. Linen lockers and hampers for soiled linen should be kept locked at all times and the nurse or hospital corpsman in charge of the ward should carry the keys which are turned over to their relief on going off duty. Damage to linen should be avoided by the use of protective pads and by care in giving and removing bed pans and urinals. Torn linen should never be used but sent to the linen room for mending, folded with the torn side out or with the damaged part indicated by marks made with a soft-lead pencil. There should be a designated time to issue clean linen in wards, and each patient up and about should bring his soiled linen to be exchanged for clean. Nurses or hospital corpsmen are responsible for the exchange of bed patients' linen which is changed as often as necessary for their comfort and cleanliness. Ambulatory patients should have their bed linen and pajamas changed not oftener than twice a week although towels may be exchanged every morning. The nurse or hospital corpsman in charge of a ward should take property and linen inventories personally, counting linen weekly and blankets daily. For cases requiring treatment which will stain linen,

such as genito-urinary cases, burns, scabies, etc., old, repaired linen may be used.

It is inevitable that linen should become stained and the removal of stains is a part of the care of linen. Before being sent to the laundry all possible stains must be removed.

Stains from blood, defæcation, vomitus, medications, or dressings should be removed immediately where at all possible, and always before sending linen to the laundry in order that they may not become fixed and render the linen unfit for use. *Blood stains*, when fresh, are removed by soaking in cold water, then washing in warm (not hot) water and soap. Stains on a mattress are removed by applying a starch paste to spot, allowing it to dry, then brushing well. Repeat the process until the spot disappears. *Vomitus* and *fæces* are removed by holding under cold running water and brushing, then washing with soap and water. *Fruit stains* are removed by pouring boiling water through the stain until it disappears. *Meat* and *egg stains* are treated in the same manner as blood stains. *Iodine stains* may be removed by soaking the stain in sodium thiosulfate solution. *Stains of silver preparations* are removed by soaking the stain in salt solution and rinsing in clear water, or by covering the spot with tincture of iodine and after a few minutes washing with alcohol, ammonia water and clear hot water. *Ink stains* may be removed from linen by the application of lemon juice and salt, afterwards putting the material in the sunlight to dry and then washing with warm water and soap. If the stain does not disappear at once, repeat the process. *Potassium permanganate* stains may be removed by washing it in a solution of oxalic acid, followed by ammonia water, and then rinsing in clear water. *Vaseline stains* may be removed with kerosene and hot water and soap. *Rust stains* on fabrics may be removed by washing in warm oxalic acid or citric acid solution (if the colors will bear it) and rinsing in water. *Mercurochrome stains* on colorless cotton or linen cloth are removed by soaking the material in a 20 per cent chlorinated soda solution (Labarraque's solution) for 2 minutes, then adding 5 per cent solution of acetic acid in an amount equal to about one-fifth the volume of the soda solution. The cloth should be agitated to hasten the results. These stains are very difficult to remove from cloth fabrics. Repeated washing and rinsing is all that can be recommended. *Bichloride of mercury* makes an ugly, gray-colored stain in linen which is exposed to the heat of washing and ironing. Linen which has been wet with bichloride of mercury should be soaked for several hours in Labarraque's solution and then thoroughly rinsed and washed as the solution is injurious to fabrics when used in full strength. *Oil* or *grease stains* may be removed by washing the stains with ether, benzine, or gasoline. This must not be done near an open flame as these substances are highly inflammable.

Be sure and wash with clear water following the removal of any stains, and always be sure that linen is dried before it is put in the linen hamper. Do not apply hydrogen peroxide to any fabric for the removal of stains, as it tends to destroy the fibers of the fabric.

While discussing the removal of stains from linen it is well to mention some of the ways in which stains may be removed from sinks, utensils, etc. *Rust stains* on iron and steel may be removed with kerosene, but care must be taken to apply kerosene to a stove at such time that it will have evaporated before the stove is used. This precaution is necessary because of the inflammable nature of kerosene. *Rust* or *other stains* may be removed from granite and enamel ware by washing with kerosene, hot water, and soap. All utensils should be dried thoroughly before they are put away, in order that rusting may

be prevented. If alcohol is spilled on a white enamel surface, oil should be applied to the spot before attempting to remove the alcohol. This is necessary because the enamel is soluble and may be removed by the alcohol. *Acid* destroys the polish on marble, therefore an alkali should be used to neutralize and remove the acid. If orange or lemon juice is spilled, ammonia and soda applied immediately will prevent a stain.

Mercurochrome stains on the skin are easily removed, when fresh, by acidulated alcohol; when fixed, by the application of Labarraque's solution or any other "hypochlorite." If, in the latter case, a dilute acid is used following the hypochlorite, the action will be more prompt.

General care of the ward.

It is essential that certain conditions in wards be maintained by the nurses or hospital corpsmen in charge. These conditions are: Proper ventilation, freedom from unpleasant odors, uniform temperature (the degree required depending upon the diseases in the ward), proper lighting, cleanliness, definite places for furniture and utensils, and furniture and furnishings kept free from stains and defacement.

To have proper ventilation in a ward the incoming air must be pure, and the air in the ward kept in circulation without causing a draft. When windows are opened they should all be raised or lowered a uniform distance, and window shades should be kept at a uniform height. Exposure of patients should be avoided by having them sufficiently covered when the windows are opened to air the ward. To prevent unpleasant odors in wards bedpans should be covered when carrying them through the ward, and should be clean when not in use; bed linen may be kept free from fæcal odor when giving an enema by using a blanket which can be aired; patients and bedding should be absolutely clean; dressing and garbage pails should be kept covered, emptied frequently, and kept clean; hoppers and toilets should be properly flushed and a deodorant or kerosene used frequently; and waste pipes, sinks, and hoppers should be free from obstruction.

A low temperature, providing the patient's body is kept warm, often will act as a respiratory and circulatory stimulant. Patients who are restless and excited frequently become quiet and go to sleep out of doors or in a cold room, while, on the contrary, patients become restless and do not sleep well in a hot ward. Patients with chronic diseases, associated with poor circulation and anæmia, usually require warmer surroundings than fever patients, while those in shock and under the influence of an anæsthetic temporarily require a still warmer environment. The average ward temperature should be 68° F. during the day and 65° F. at night. The temperature of the operating room should be 78° F., that of the recovery and treatment rooms 72° F., and that of the bathrooms 72° F.

Direct rays of the sun are the very best air purifiers and germ destroyers, and a ward or room should have as much sunlight as possible, preferably unfiltered, direct rays. Artificial light should be by the indirect lighting method, but where other methods of lighting are used, shades, screens, and the position of the bed should be so arranged that the patient's eyes are adequately protected from glaring or direct lights of any kind. Strict economy should be practiced in the use of artificial lights, by turning them off when not needed. Exposed or defective wires should be reported at once, thus preventing danger of fire and accident.

Furniture in a ward should be arranged uniformly, and in straight lines if practicable. No accumulation of articles on beds, chairs, or lockers should be

permitted, and clothing and other articles must not be stowed under the pillows or the mattress. Service clothing should be rolled or folded neatly and placed inside the locker, the shoes on under-shelf of locker. Window sills and radiators should never be used for holding debris nor for hanging clothes. All articles broken, missing, or in need of repair should be surveyed or repaired promptly.

Admission and discharge of patients.

The actual care of a patient begins on his admission to the ward. On his arrival in the ward he should be given immediate attention, should be received with courtesy and kindness, made to feel that he is expected, and that everything possible will be done for his comfort and quick restoration to health. A general air of friendliness and quiet order in a ward helps greatly in gaining a patient's confidence and cooperation.

If the patient is an ambulatory case, and not too ill, he should not be assigned a bed at once, but given, if available, a seat near the ward desk while routine records, slips, temperature, pulse and respiration are taken and recorded. Then, supplied with pajama suit, towels, and soap, he should be shown the bath and toilet rooms, and instructed to take a tub or shower bath before going to bed. If not put to bed, he should be instructed to "stand by" near his bed until seen by a medical officer or given permission to leave the ward. Patients up and about should be informed of the hours of sick call, the times their medicines and treatments come due and the time meals are served, and instructed to be always on hand for each unless excused.

If the patient is brought to the ward in a stretcher, has a temperature of 100° F. or over, or shows evidence of acute illness, pain, weakness, or injury, he should be put to bed immediately and all data and information taken at his bedside, after which he should be given a bed bath. All symptoms and evidences of disease or injury should be noted and reported to the nurse or hospital corpsman in charge of the ward who reports them to the medical officer who examines the patient. At the time of bathing the patient's body should be carefully examined for eruptions or vermin. If an eruption is present the patient may have a contagious disease and should be kept away from others until seen by a medical officer; if vermin are found the steps necessary to rid him and his clothing of them and prevent their spread must be taken as soon as possible.

An admission card should be filled out for the record office, being sure to give the full first and middle names of the patient as initials are not enough. If a duplicate is sent to the officer of the day the patient's temperature, pulse, and respiration at the time of admission should be recorded on it. Do not fail to ascertain the patient's religion, and the name and address of his nearest relative, friend, or guardian. This is most important, as any patient at any time may suddenly take an ill turn or meet with an accident, when it would be necessary to at once call a priest or minister, and notify relatives or friends.

Each ward has an admission book or card index of patients in which is recorded a duplicate of the record on the red admission card. This must be complete, and available day or night to the nurse or hospital corpsman on duty. When a patient is admitted from another ward he brings a "transfer slip" with him from that ward, but an admission card is not made out as that was done by the first ward. The complete data, however, are obtained from the patient or his records, and entered in the ward admission book the same as if he were a new admission.

Each ward has a "bed list" or "bed roster", a ruled sheet of foolscap on which the beds are numbered in the order in which they are placed in the ward. The patient's name, rating, diagnosis, and date of admission to the ward are placed opposite the number of the bed assigned to him. If, later, for any reason the patient's bed is changed, his name on the bed roster is changed correspondingly. This is very important, as a morning and evening checkup of patients is made, and a list of absentees sent to the officer of the day. As changes are frequently made necessary on this roster, because of transfers, discharges, etc., it is wise to make it out in pencil. Then, as changes occur, erasures are easily made and the changes can be recorded immediately. This is very essential as this list must be complete and correct at all times, and available as a reference for medical officers, nurses, and hospital corpsmen on duty in the ward, and for executive heads of departments who may make inquiry at any time. At a glance the number of patients in the ward may be ascertained, also the number of empty beds available for new patients. All patients on leave are carried on the ward census and listed at the bottom of the roster, but no beds are assigned them. Patients absent without leave (A. W. O. L.) or over leave (A. O. L.) are dropped from the roster at the end of 10 days.

On each bed should be a tag or card on which the patient's name, rating, religion, diagnosis, and date of admission are recorded. This should be made out at the time of admission with the other admission forms.

As soon as possible the patient's temperature, pulse and respiration should be recorded on his clinical chart, together with his name, rating, diagnosis, color and religion. On the clinical notes are recorded the time of admission, name and rating of patient, whether he is a stretcher or an ambulatory case, his admission diagnosis, any orders received from the officer of the day with the patient, any immediate treatment given, and any symptoms noted, especially those complained of by the patient.

Next to the clinical notes and chart is placed the clinical record, for the medical officer's use when he makes the physical examination and starts the history of the case.

A laboratory request for routine urinalysis is made out for all new patients on admission, and sent, with the specimen, on the following morning to the laboratory. Requests for laboratory examinations of other kinds are sent as ordered by the medical officer. When an unconscious, delirious, or demented patient is admitted, get all possible data and information from the friend coming with him, including a list of any valuables or clothing.

The clothing of patients should be removed as much under cover as possible, and with a minimum of discomfort to the patient and injury to the clothes. In case of injury the procedure must be modified to suit conditions, garments being removed from the injured part last. When necessary for the comfort and safety of the patient, or when, because of his serious condition, time is of the utmost importance, rip, tear, or cut the clothes at the seams and remove them as speedily as possible.

All infectious cases must be isolated upon admission. List the clothing, place in a bag or other cover, tag properly and send to the sterilizer. Furs, skins, leather goods, etc., will not stand sterilization by steam.

All property is valuable to its owner and precautions must be taken to safeguard the belongings of a patient. In the bedside locker may be placed toilet articles, clothing actually needed during illness or while convalescing, intimate personal effects, writing materials, papers, books, magazines, playing cards, or work from the vocational therapy department. These articles should

be arranged neatly and in order, with the idea of tidy appearance and easy access.

All money and valuables of a helpless patient, and other patients when desired, are listed, preferably by two people, in the presence of the patient or his representative, and then placed in an envelope marked with the patient's name, rating, ward, date, list of contents, and signed by the person making the list. The above property is then turned over for safe-keeping to the executive officer who issues a receipt which the patient holds until his convalescence or discharge, when he returns it to the executive officer and receives his property.

The bag and hammock, and any baggage or articles of clothing not required for use of the patient during his illness are properly tagged, locked, and sent to the bag room where they are listed and kept under responsible supervision.

If money, valuables, or clothing are turned over to relatives of a patient, a receipt should be obtained from them.

As soon as possible the medical officer makes a physical examination of the patient for the purpose of obtaining a complete history and making a diagnosis, and to determine the treatment. All articles required by medical officers should be available at the time of examination. A conscious patient should be told something of the examination which is to be made, and what will be required of him during the procedure. A nervous patient should be reassured, made as comfortable as possible, and encouraged to relax and lie at ease. The examining room should be warm, as chilling prevents relaxation. The patient should be protected from unnecessary discomfort and exposure, placed in the required position, and the assistant should anticipate by close observation and intuition the wishes and requirements of the medical officer. The ward or room should be quiet and have the best possible light. Positions of the patient depend upon the purpose of the examination, the part to be examined, and the condition of the patient.

Patients are discharged from treatment for various causes such as recovery from the condition for which admitted, death, physical disability, transfer to other hospitals, etc.

In order that the patient's records may be ready at a designated time, a list of the names of all patients ready for discharge is signed by the senior medical or surgical officer and sent to the record office at least 24 hours before date of discharge. Charts and records are closed out and sent to the designated office. On the morning of discharge a card with the patient's name, rating, number of ward, and date is sent from the personnel office to the ward from which patient is to be discharged. This card is signed by the ward medical officer and by the nurse or the hospital corpsman in charge of the ward and delivered to the patient, who presents it at the bag room as identification before receiving his baggage; to the librarian, in order to make certain before his departure that all books charged to him have been returned; and at the post office to inform the mail clerk of his change of address. The card is then returned to the personnel office, and the patient is ready to depart. A record is also made on the ward census report of the following morning. The date of discharge is also checked (in red ink) opposite the date of admission in the ward admission book.

When death of a patient is expected the hospital corpsman and others in attendance must be careful to assume the right attitude. Their manner should be sympathetic and attentive, both to the patient and to his relatives. A dying patient should be separated from other patients in a ward, either by transfer to a quiet room or by being screened in the ward; he should never be left alone. It should always be borne in mind that a dying patient, although apparently unconscious, may hear and understand much that is said near and

concerning him, and for that reason no unnecessary conversation should be carried on in his vicinity.

If a medical officer is not at the bedside when death occurs one must be notified when respirations have ceased, so that he may officially pronounce him "dead." As soon as the patient is pronounced "dead" and the relatives have left the procedure with regard to the body and the disposition of the effects should be as described in the section on "Deaths and Medico-legal Matters.

Section 3.—OPERATING ROOM AND SURGICAL TECHNIQUE

When one speaks of an operating room it is usually with a broad meaning that includes not only the room or rooms where operations are actually performed but all the other rooms connected and associated with them, all of which constitute the operating suite. This section of a hospital or a hospital ship or of the sick bay aboard ship is a most important place, and upon its equipment and care depend to a considerable extent the success or failure of an operation. Of course surgeons often are required by necessity to perform operations under conditions far from satisfactory; for instance, under war conditions or in isolated farmhouses. However, whenever possible, operations of a major character should be performed in hospitals where the patient can be safeguarded by all possible aseptic conditions.

The operating room.

The administration of the operating room or operating suite is one of the duties of the chief of the surgical service, the Manual of the Medical Department directing that he shall be in charge of all operating rooms and their accessory treatment rooms, and that he shall issue necessary instructions to nurses and hospital corpsmen regarding procedures and technique.

The operating suite of a modern hospital should be in a location as free from miscellaneous hospital traffic and noises as possible. It consists of the operating room or rooms and various accessory compartments arranged in a convenient order. There are usually at least two operating rooms so that one is always ready for use while the other is being cleaned or repaired, the main room being used for clean surgery and the alternate one for the dirty or pus cases. In an emergency both may be used simultaneously.

The actual size of an operating room should be determined by the number and character of operations to be performed and the space available; it should be sufficiently large to preclude the necessity of crowding yet not so spacious that it is difficult either to clean, ventilate or heat.

Lighting.—When natural light is used, a northern exposure is preferable because there is less variation in the intensity of the light from that direction. However, if large north windows are used in a cold climate, one must consider the danger of placing the operating table too close to the window. Little dependence is now placed on natural light, since artificial light is much more dependable and easily controlled. Overhead adjustable top lights are now made with the rays focused from a number of reflectors to reduce shadows on the field of operation to a minimum. These are even more effective when the new spot-beam portable light is used in conjunction with them. Side lights are also in use, and are arranged to work with batteries should the electric current fail.

Heating and ventilation.—The temperature of the operating room is kept at about 80° F. during operations and the ventilating system should be capable of maintaining this temperature during the coldest weather likely to occur in

the locality. Many of the modern hospitals are equipped with an air-conditioning unit. There are two main types of air-conditioning equipment, the unit installation and the central-plant system. Unit installations are used to cool, heat, humidify, clean, and circulate the air in the particular rooms in which they are located. The central-plant system differs in that the air is conditioned in a central plant and then distributed through ducts to the various rooms.

Direct or natural ventilation is used chiefly in small hospitals, and must be as nearly perfect as possible. Fresh, clean, warm moist air should be constantly provided and drafts avoided.

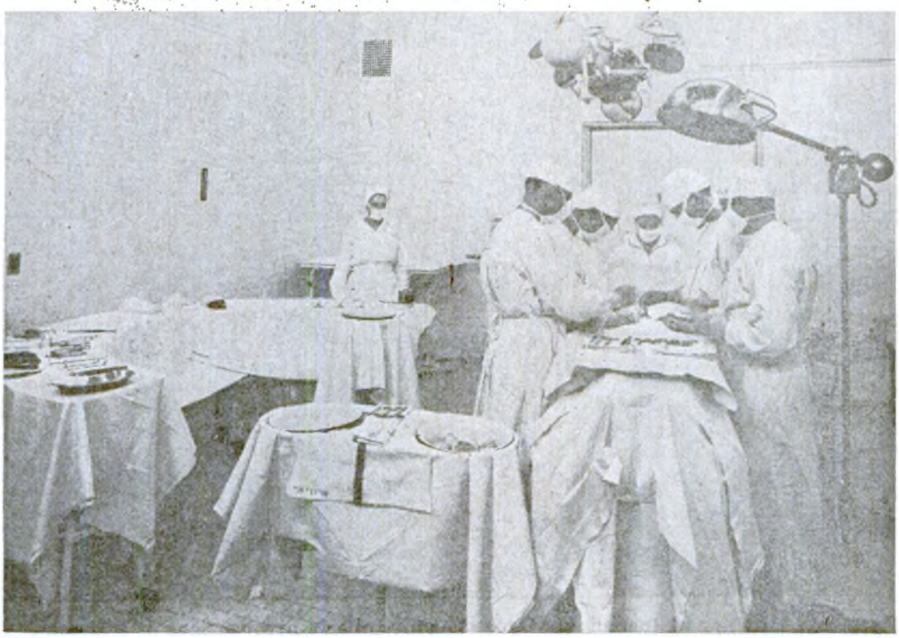

FIGURE 115.—View of an operating room at time of operation showing arrangement of furniture, positions of personnel, conventional operating dress, and type of lighting.

Equipment.—An operating table with all accessories, adjustable as to height and the various standard positions, is desirable, but this type of table is expensive, and quite as good work may be performed on one of a simple design, provided proper forethought is given the type of operation and the required position of the patient. On the table there should be a soft pad about 1½ inches thick covered with rubber sheeting and over all a linen sheet. In addition to the operating table but few pieces of apparatus are necessary. There should be two or three tables with glass or polished metal tops—preferably metal—for surgical dressings and instruments to be used during the operation, one single and one double hand basin stand, an irrigating stand, two enamel buckets with covers, and a set of glass shelves for solutions, ligatures, drains, pins, etc. All the operating-room accessories should be of simple, sturdy, easily cleaned design, and should be painted with a durable white enamel.

Each table in the operating room holds certain specified articles placed in a definite way so that no time is lost in hunting for the desired article.

On the large table (Fig. 115) are kept special instruments, reserve instruments, reserve sutures, and linen. At the far end is laid out the preparation equipment for sterilization of the operative field.

There is a double basin stand placed near the foot of the operating table within easy reach of the instrument nurse; one basin contains sterile water for dipping the suture materials or for soaking tape sponges, the other basin contains the dry tape sponges. On this same stand between the basins, the dry sutures are neatly arranged in a dry towel for immediate use.

The instrument tray or table which extends over the operating table holds instruments arranged in regular order (Fig. 116). This table routinely holds knives, various scissors, plain and toothed thumb forceps, curved and straight hæmostats, Allis' forceps, Babcock's forceps, gauze sponges, stick sponges, various retractors, probes, and grooved directors.

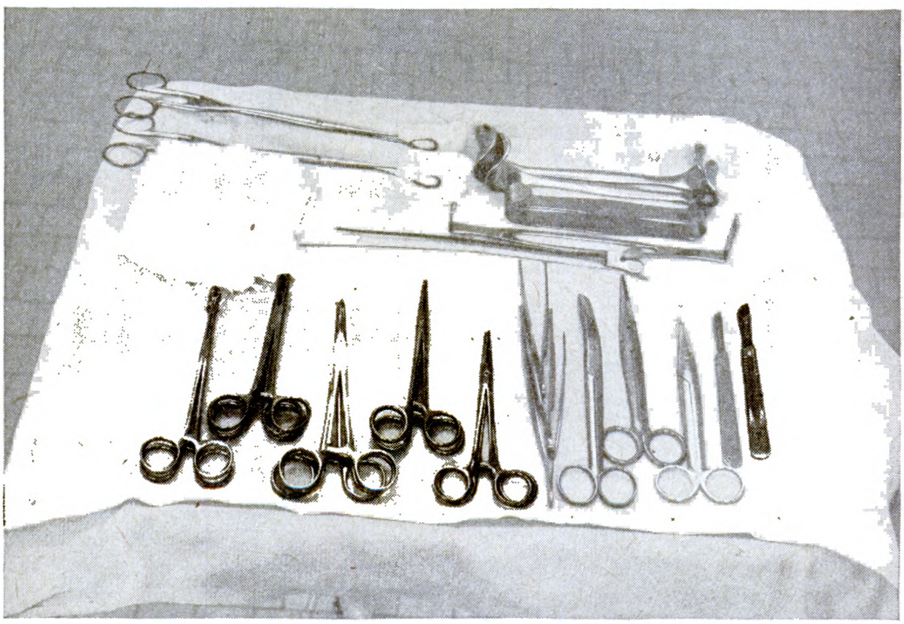

FIGURE 116.—View of instrument table showing orderly arrangement of instruments.

A stand with a hand basin for sterile water is behind the surgeon for rinsing his gloves during the operation if necessary.

Conveniently located, either in the scrub room or in the operating room near the entrance from the scrub room, are placed basins for solutions to sterilize the previously scrubbed hands of the surgeon and assistants.

A table is provided near the entrance from the scrub room to hold sterile gloves and gowns.

The anæthetist's table for general anæsthesia, in addition to the articles necessary for the administration of the anæsthetic and an extra supply of the anæsthetic, always should have the following equipment on it and immediately available for use in an emergency:

(*a*) Wooden mouth gag.

(*b*) Tongue forceps.

(*c*) A curved needle threaded with silk, sterilized, and in a sterile package.

(*d*) Sterile hypodermic syringes with the following drugs in sterile solution in appropriate containers:

Caffeine sodium-benzoate.
Atropine sulfate.
Epinephrine hydrochloride (adrenalin).

(*e*) Tracheotomy set.
(*f*) Gauze strips.
(*g*) Forceps (to hold gauze sponge).
(*h*) Watch or small clock.
(*i*) Pus basin.
(*j*) Blood-pressure apparatus.

This equipment should be within easy reach and it never should be necessary to ask for any of these important articles during anæsthesia, as delay in meeting an emergency may result in disaster. It is also desirable to have an anæsthetist's chart for the recording of data on the table.

Some cases require gastric lavage (washing out of stomach) during or upon completion of operation. It is essential, therefore, that a stomach tube be available in the operating room.

Cleanliness.—The walls and floor of the operating room are usually built of waterproof material with a smooth surface and so constructed that sharp, dirt-collecting angles are avoided. Glazed porcelain tile for the walls and unglazed porcelain tile for the floor are admirably suited for the purpose in hospitals on shore, but on battleships, while it may be possible to have a tiled floor, the walls are usually steel, painted white, because the great vibration caused by gunfire might loosen or crack a tile wall. The floor should be washed daily with soap and warm water and all surfaces that might collect dust wiped with a damp cloth, the glass-topped tables, that are usually draped sterile, being wiped with a cloth dampened with alcohol. Once a week, usually on field day, furniture, walls, floors, etc., are thoroughly scrubbed with soap and water, special care being taken to scrub and clean all corners and crevices. Blood or other stains that may get on the floor during an operation should be removed as quickly as possible, and, if a second operation is to be performed immediately, the floor, if necessary, should be cleaned by hand.

Adjoining rooms.

The rooms, other than those used for operating, that comprise the operating suite are usually the anæsthetizing room, the wash or scrub-up room, the sterilizing room, the instrument room, the surgical-dressings room, the store-room, and the cleaning-gear room.

The *anæsthetizing room* is suitably equipped for the administration of anæsthetics.

In the *wash* or *scrub-up room* there should be at least two lavatories, with foot or knee control for the hot and cold water, a shower bath and toilet, and clothes lockers for the use of the surgeon and his assistants when they change into the operating suits. It is well also to have in this room a basin stand for the solutions used to disinfect the hands after the preliminary scrubbing, in order that the surgeon and his assistants can receive their operating gowns and proceed without delay.

The *sterilizing room* is provided with all equipment necessary to properly sterilize instruments, utensils, dressings, water, etc. Despite the fact that this equipment is sturdily constructed, constant care must be taken that it is always in working condition and the printed directions furnished by the manufacturers exactly observed. Operation of this equipment should never be entrusted to an inexperienced or careless person, for in inexperienced or careless hands it is dangerous, and may fail to kill infectious organisms, thereby endangering the lives of patients.

An *instrument room*, while not a necessity, is advantageous. However, as a rule, unless the clinic is unusually large and of great variety, suitably designed glass cabinets placed in the surgical-dressings room will suffice.

The *surgical-dressings room* should be constructed similarly to the operating room, with tiled walls and floor. In this room are made, prepared, and stored, after sterilization, the various surgical dressings and packages of linen, such as gowns, sheets, towels, etc., used in operations. Here cleanliness is of paramount importance. Ample locker and shelf space should be provided, and also a large smooth-top worktable.

There should be a *storeroom* solely for the storage of operating-room supplies. Much valuable time may be lost unless such a room is provided and kept fully stocked in anticipation of emergencies.

The *cleaning-gear room*, in which all cleaning gear used in the operating suite should be stowed, should have in it a large deep sink with running hot and cold water, in which the linen used during operations may be soaked and the greater part of blood stains removed before sending to the laundry. The cleaning-gear room, it should be remembered, is an integral part of the operating-room equipment, and as such must be scrupulously cared for.

SURGICAL TECHNIQUE

Modern surgical technique is founded on the work of Lord Lister, who, in March 1867, published the first of a series of articles on the antiseptic principles of the practice of surgery. From this work has been evolved the modern aseptic methods which aim to prevent the entrance of microörganisms into the tissues. These aseptic precautions account for nearly all the details of present-day operating room technique.

Before an operation it is necessary to make sterile and to keep sterile: 1. The patient's skin; 2. The hands and clothing of the surgeon and his assistants; and 3. All instruments and materials that come in contact with the wound or are handled by the surgeon and his assistants.

During the operation the surgeon and his assistants must not touch anything that is not sterile. A great responsibility rests upon the operating room hospital corpsmen, because the most perfect surgery may be a complete failure if there is the smallest break in the aseptic technique for which they are responsible. It follows, then, that a great deal of credit for the success of surgery in the Navy is due to the nurses and hospital corpsmen of the operating room detail. It is their efficiency that makes aseptic surgery possible.

By **aseptic surgery** is meant that mode of surgical practice in which everything used at the time of operation and at subsequent dressings, as well as the wound, is free from pathogenic bacteria and is sterile, or surgically clean. To maintain that condition requires constant vigilance before, during, and after an operation, and no failure of technique however trivial, must be allowed to pass uncorrected.

Infection is the word used to describe the condition which exists when pathogenic bacteria, commonly spoken of as infectious organisms, gain access to the tissues of the body in such numbers that their presence is manifested by characteristic symptoms, such as inflammation, suppuration, putrefaction, etc.

Inflammation is the first objective or outward symptom of infection and is characterized by local pain, heat, redness, swelling, and disordered function. The general or subjective symptoms of inflammation vary greatly, depending upon the amount and anatomical location of the tissue involved, the physical condition of the patient, and the virulence (disease-producing power) of the infecting organism. Fever is the most constant subjective symptom of inflammation, but it may be so slight that it escapes notice or it may be so severe that recovery of the patient seems doubtful. Aseptic treatment and careful observa-

tion of wounds, traumatic or operative, is imperative, in order that in the first place infection with its subsequent possibilities may be prevented and, secondly, if infection does occur it may be recognized promptly and appropriately treated.

Suppuration is the result of inflammation and is due to the liquefying action of pyogenic (pus producing) organisms on the exudates of tissues damaged by inflammation and also upon the tissues themselves, forming pus.

When a wound has become so infected that the inflammation does not subside and pus forms, it is termed a "septic" wound. Frequently, as a result of the passage of bacteria from a septic wound into the blood stream or of the absorption of the toxins (poisons) elaborated by the bacteria, grave general symptoms are caused and *sepsis* or *septicæmia* (blood poisoning) is said to be present.

The word *putrefaction* refers to that condition when inflammation has so far progressed that the tissues have been devitalized and a foul or putrid odor arises from the wound. The putrid odor is due to the action of putrefactive bacteria.

The microörganisms producing pus are known as *pyogenic bacteria.* The various strains (varieties) of the staphylococcus and streptococcus are the causative agents in the majority of surgical infections. Other organisms such as the *Mycobacterium tuberculosis* (*hominis*), *Bacillus anthracis* (*Bacillus of anthrax*), *Actinobacillus mallei* (*Bacillus of glanders*), *Diplococcus pneumoniæ, Escherichia communior, Clostridium tetani* (*Bacillus of tetanus*), and *Clostridium welchii* (*gas bacillus*), are, however, occasionally demonstrable. The *staphylococcus* is the most common cause of infection. It rarely causes alarming constitutional symptoms, and as a rule such an infectious process remains quite localized. The *streptococcus* is more virulent and tends to invade the whole system. Infection of wounds by one type of organism is quite rare; two or more varieties usually are present and the coincident symptoms are dependent upon the predominating bacterium, either because of its virulence or numbers. It is well to note that the encapsulated spóres or buds of the bacillus anthracis are the most difficult of all germs to kill, and any process which will render them harmless (and they must be dead to be harmless) may be relied upon to accomplish the same result as regards the other bacteria.

The *prevention of infection* is the best treatment known for this condition. Infection is prevented through the employment of measures that destroy infectious bacteria and their spores or inhibits or stops their growth. These measures make up that process in surgical technique known as *sterilization.*

Sterilization is the process of rendering anything sterile by destroying infectious organisms and their spores, and is accomplished by mechanical, thermal, and chemical methods. Sterilizing agents are substances which destroy or remove or prevent the growth of infectious organisms.

The methods used in *mechanical sterilization,* while not dependable, are important preliminary steps to more complete methods of sterilization. The most important of the mechanical methods of sterilization are scrubbing and irrigation.

A thorough *scrubbing* with hot water, soap, and brush is frequently of great importance as it removes dirt which may harbor harmful bacteria from the walls and floors of operating and treatment rooms, from instruments and utensils, the hands of the surgeon and those assisting at operations and dressings, and the skin of the patient. Instruments and utensils should always be cleaned and scrubbed immediately after use as that removes most of any bacteria present and makes subsequent sterilization more easily effective.

The *irrigation* of wounds with sterile water or other aqueous solutions to float off or dislodge by force dirt and bacteria, or to bring solutions in contact with parts of a wound which are not otherwise accessible, has a distinct place in surgical practice. Irrigation is a splendid mechanical cleanser and, in many cases, will remove infectious organisms when other methods fail.

Thermal sterilization, or sterilization by heat is the most efficient agent of sterilization, and, when properly used, is almost certain in its germicidal action. Moist heat is used as a sterilizing agent in two forms, boiling water and live steam under normal or increased pressure.

Boiling water is the simplest method of sterilization, killing anthrax spores in 3 minutes, and is used chiefly for sterilizing instruments (except those with lenses), glass and metal utensils, enamel ware, and other objects which are not injured by heat and moisture. The articles should be boiled for 20 minutes in water containing about 1 per cent (3 teaspoonfuls to the quart) of sodium carbonate, which is added to prevent rusting, to raise the boiling point of the water, and to dissolve any organic matter that may be present. In emergencies surgical dressings may be boiled, but it is far more satisfactory to have them dry at the time of operation.

Live steam is air-free steam and for sterilization purposes is used under normal or increased pressure. Steam under increased pressure is termed superheated steam and is the best method of sterilization. Steam at normal pressure is but little used at the present time.

An *autoclave* is a sterilizer in which steam under pressure (superheated steam) is used. A vacuum first is created to insure penetration of the steam, and when the proper reading of negative pressure (vacuum) is registered in the gauge superheated steam is admitted to the chamber and the articles therein subjected to a steam pressure of 15 pounds for one-half to three-quarters of an hour. At the end of this time all organisms will have been killed and the dressings or other articles rendered safe to use, but they are wet. A second vacuum then is induced and maintained until they are dry. One such sterilization ordinarily is sufficient to preclude the possibility of infection, but that there may not exist the slightest doubt as to the asepsis of the sterilized material the process is repeated two or three times, despite the fact that anthrax spores are killed by live steam in 12 minutes. This method of repeated sterilization, either by steam or boiling, is termed *fractional sterilization*.

The method of sterilization in which *dry heat* is used includes the use of the actual cautery, a flame, or hot air. Hot air is fairly satisfactory and it will kill anthrax spores in about threee hours at 140° C. The cautery is a positive germicide, but causes extensive destruction of the tissues. Sterilization by a flame is rarely, if ever, used in surgery, but may be used for rapid sterilization of platinum loops, needles, and other small instruments. Dry heat was once extensively used in the sterilization of dressings and clothing but has been largely superseded by steam under pressure which is quicker and more effective.

In *chemical sterilization* chemicals that will kill bacteria and spores are used, but in order to do this promptly they must be used in such a strong solution or concentration that the tissues to which they are applied may likewise be destroyed. As such a result is usually undesirable the use of chemicals as sterilizing agents is confined chiefly to the sterilization of instruments which boiling or steam would ruin, or in weak solution as an adjunct to the mechanical method of sterilization. Chemical solutions of appropriate strength are used in the sterilization of instruments, materials and utensils, the skin of the patient, the operator's hands, and the walls and floors of rooms. When used

in contact with the tissues the aim is to secure complete sterilization without causing damage to the tissues, but no such ideal antiseptic has yet been found.

The terms antiseptic, disinfectant, and deodorizer are often applied to chemicals according to the purpose for which they are used. When used in connection with chemicals, an *antiseptic* is an agent which inhibits or stops the growth of or kills bacteria but not the spores; a *disinfectant* is an agent which kills both the bacteria and the spores; and a *deodorizer* is an agent which destroys offensive odors. While the terms antiseptic and disinfectant have distinctly different meanings, they have been used synonymously so often that, from a practical standpoint, it is considered correct to use them interchangeably. Many chemicals may be used either as an antiseptic or a disinfectant.

Some of the chemicals used in chemical sterilization are named and briefly described immediately hereafter.

Alcohol, in strengths varying from 50 to 95 per cent, is commonly used to disinfect the hands of operators, for disinfecting cutting and sharp instruments, for cleansing and drying the skin of the operating field preparatory to the application of iodine, and as a solvent or diluent for various antiseptics.

Iodine, in strengths varying from 2 to 7 per cent, is a reliable germicide and is used for sterilizing wounds and in preparation of the skin. The 2 per cent solution is sometimes used in preparation of the operator's hands. In the presence of water the iodine is precipitated and it will not penetrate if the skin or tissues be wet. When used for skin sterilization it is usually preceded by an application of benzine or ether to remove the sebaceous matter and dry the skin. After the iodine has dried it is customary to remove the excess with alcohol to prevent burning or blistering the skin.

Bichloride of mercury is now seldom used in contact with the body although some operators use it in preparation of their hands. In weak solutions it has a powerful germicidal action on superficial bacteria, but is of little value as a germicide in deep wounds because it combines with the proteins in the tissues to form an insoluble albuminate of mercury which markedly hinders its action and penetrative power. A 1 in 500 solution in alcohol is useful in sterilizing rubber goods. As mercury has a corrosive action on metals it should never be used to sterilize instruments.

Phenol (carbolic acid) in saturated solution, is used for sterilization of cutting instruments which would be injured by boiling. They are submerged in the solution for 15 minutes, washed in sterile water and placed in alcohol until needed. It is also used for sterilization of tissues, such as the stump of the appendix, where deep penetration is not required, and as a local cauterizing agent. Phenol dressings should not be used because of the danger of subsequent gangrene.

Dakin's solution is a solution of sodium hypochlorite of strength between 0.45 and 0.5 per cent and practically neutral in reaction. In contact with the tissues it gives off nascent chlorine which destroys bacteria and dissolves the necrotic tissue in which they grow. It is rapidly decomposed by light and heat and should be titrated daily to insure the proper strength. When used according to the Carrel technique in a properly prepared wound, it is of great value.

The chloramine group of disinfectants also act by liberation of chlorine. They are more stable than Dakin's solution and give off their chlorine more slowly but they lack the important solvent action on the necrotic tissue.

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Potassium permanganate is an excellent deodorizer and, in addition, is a good disinfectant for the hands in saturated solution.

Boric acid is a very mild antiseptic and generally is used in saturated solution (4 per cent) for the irrigation of infected wounds or the sterilization of instruments which heat in any form would destroy.

Formaldehyde is an excellent germicide and is used either as a gas or in solution. It is very irritating to the tissues and seldom is applied in a dressing; in weak solutions (1 to 2 per cent) it will prove a satisfactory sterilizing solution for instruments. Formaldehyde gas in a glass jar is perhaps the most satisfactory method of sterilizing instruments which heat or moisture would injure, as catheters, cystoscopes, and similar articles. As a gas it is sometimes used in the disinfection of wounds, but this is no longer done as a routine in the operating suite.

Various substances that color or dye the skin, such as *picric acid, mercurochrome, gentian violet,* and *acriflavine* are also used as disinfectants.

The sterilizing methods used in the operating suite at the Norfolk Naval Hospital, Portsmouth, Va., are here given as an example of a satisfactory routine.

Large packs are sterilized for 60 minutes under 20 pounds pressure with 20 to 30 minutes vacuum allowed for drying. Small packs are sterilized for 30 minutes under 20 pounds pressure with 15 to 20 minutes vacuum allowed for drying. Enamel ware, glassware, and rubber goods are sterilized for 15 minutes under 15 pounds pressure with no vacuum. Solutions in flasks are sterilized separately for 15 minutes at 15 pounds pressure. Pressure, at conclusion of sterilization period, is allowed to decrease gradually. No vacuum is used on solutions. Sharp instruments are sterilized in oil in a hot-oil sterilizer at a temperature of 250° F. and above for 15 minutes. Sharp instruments can be sterilized by placing in an 87½ per cent solution of phenol for 15 minutes, rinsed in plain sterile water and placed in 95 per cent alcohol for 20 minutes. Other instruments are placed in trays and boiled for 20 minutes. A 1 per cent solution of sodium carbonate (3 teaspoonfuls to the quart) raises the boiling point about 5 degrees, prevents rust, and removes grease and other organic matter. Gloves are cleaned, inspected for holes, dried, then powdered well and evenly on both sides with talc. The cuffs are turned back for 2 inches. Each pair is placed in a muslin envelope of 4 thicknesses with a small powder bag. This is wrapped in a muslin cover and sterilized for 15 minutes under 15 pounds pressure.

Both chemical and bacteriological controls are used to insure proper sterilization, and laboratory cultures of all packages are frequently taken.

Basins are boiled in a special sterilizer for 1 hour.

The suture materials which are dispensed in tubes have been rendered sterile by the manufacturer. The tubes themselvs are sterilized in 2 ways. If the tubes are marked "boilable" they are sterilized by boiling with the instruments for 15 minutes. If they are not marked boilable, they are stored in 5 per cent phenol solution and then placed in 95 per cent alcohol for 20 minutes just prior to operation.

Suture materials such as silk and linen not dispensed in tubes are sterilized in the autoclave under 15 pounds pressure for 15 minutes. Horse hair, silkworm gut, silver wire, etc., are sterilized by boiling for 15 minutes prior to operation.

Surgical dressings.

Surgical dressings commonly are made from gauze, cotton, flannel, rubber, linen, etc., by the operating-room force. The gauze and cotton should be of good quality and capable of rapidly absorbing fluids.

It sometimes happens that the gauze, as received from the manufacturers, is sized—that is, coated with a starch preparation which makes it unfit for surgical use—and such gauze must be boiled in a 1 per cent solution of sodium carbonate in order to remove this sizing.

Sponges are used for many purposes and are made of gauze, either rolled in a ball or flat. The flat sponges are of various sizes from 4 by 4 to 4 by 8 inches and are usually of from 6 to 8 thicknesses of gauze. All raw edges are turned in. Sponges are wrapped in muslin wrappers for sterilization.

Packs, or taped sponges, are used for surrounding the field within the abdomen. They are made of 6 or 8 layers of gauze, with all the raw edges turned in and sewed. To avoid leaving them in the abdomen, a tape is sewed to one corner, and to this a metal ring is secured, or a hæmostat may be clamped to the end of the tape. The common sizes of packs are 12 by 12 inches, 12 by 6 inches, 12 by 3 inches, and 2 by 10 inches. For sterilization they are placed in muslin covers or bags, each package containing a definite number and so labeled. During the operation the nurse or hospital corpsman in charge of them must know the exact location at all times of every pack that has been issued.

Pads consist of various thicknesses and sizes of absorbent cotton wrapped in an outer covering of gauze. They are used in wound dressings for absorbing fluids and to protect the tissues from pressure.

Sheets and *towels* are folded in a certain manner and wrapped, a definite number in each package, in a small muslin cover for sterilization.

Caps and *masks* are worn to prevent infection by dandruff or secretions from the mouth and nose. They are enclosed in muslin wrappers, sterilized and placed in the surgeon's dressing room.

Pajamas are worn in place of their outer clothing by surgeons and hospital corpsmen during operations. (Fig. 117). They may be used as they come from the laundry or if preferred they may be sterilized.

Operating gowns are of a standard type in the Navy and are worn by all persons present at an operation. The hospital corpsman who is first to scrub up usually holds the gown for the others. When putting on a sterile gown one should avoid touching the ungloved hand to its outside.

In preparation for emergencies a hospital or a ship should have on hand a considerable quantity of sterile goods. They may be placed in metal drums or in packages, each containing a standard outfit for an operation. These should be sterilized once a week if not used. Such an emergency outfit may consist of the following articles which are sufficient for the ordinary operations: 6 sheets; 1 laparotomy sheet; 12 surgical towels; 12 field cloths; 6 hand towels; 1 tray cover; 1 sacral sheet; 2 plain covers; 3 operating gowns; 1 can of glove talc; and a small bag containing the following articles: 24 "prep" sponges; 4 large, 4 medium and 4 small packs; 24 flat sponges; 1 skin towel; 1 test tube containing 2 safety pins; 1 roll of binding tape; applicators; 1 appendix apron and Diak controls.

To pack such an outfit a double muslin cover is laid out smooth, a sheet folded in the middle is placed on it, and the articles listed, stacked neatly, are placed on the sheet. The ends of the sheet are brought together, then the outer cover is pinned together and the whole package is sterilized. When needed, the outer cover is unpinned and serves as a cover for the sterile goods table.

Sutures and ligatures.

There are two principal kinds of sutures and ligatures, absorbable and non-absorbable. The principal varieties of absorbable sutures are plain gut, chromic

gut, and kangaroo tendon. Gut sutures are made from the submucous coat of the intestine of the sheep; they are used in the deep tissues such as peritoneum, muscle and fascia. The plain gut is supposed to last from eight to ten days in the tissue. Chromic gut sutures are prepared in four types, to last 10, 20, 30, and 40 days in the tissue, but the rate of absorption is very variable. Gut sutures come in various sizes from 0000 to 4. They are usually issued in plain glass tubes which may be sterilized by boiling or submerging in a special suture sterilizing solution such as potassium-mercuric-iodide solution 1—8000 in 95 per cent alcohol. Kangaroo tendon is much stronger and heavier than the gut and lasts about 30 days in the tissue.

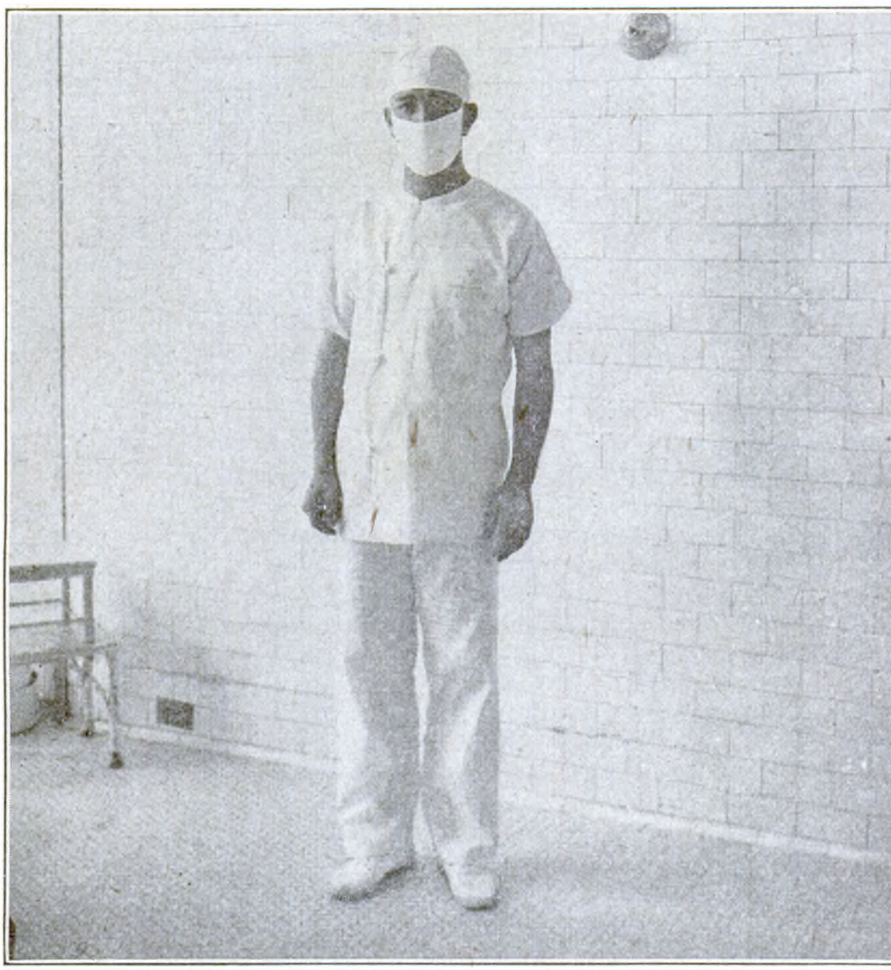

FIGURE 117.—Operating-room dress.

The introduction of the atraumatic intestinal suture has been a great step in minimizing suture trauma, as the suture is attached to the needle in such a manner that the perforation made by the needle is not enlarged or traumatized by the entrance of the suture itself. These sutures are made in both plain and chromic from size 0000 to 2 and may be used for all membranes where minimized suture trauma is desirable.

Nonabsorbable sutures are made of silk, linen, silkworm gut, horse hair, silver wire and other materials.

Instruments.

Most surgical instruments are made of special steel, and are nickel plated to prevent rusting. The newer instruments are made of stainless steel which is not plated and prove highly desirable in that they do not chip and show no wear from sterilization and scrubbing. They are kept in a special cabinet when not in use.

After an operation all metal instruments should be washed carefully to remove all blood and other foreign matter. They should then be dried and carefully examined for dirt in the crevices, breaks in the plating and sharpened if they need it. They are then wiped with liquid petrolatum or typewriter oil to prevent rusting and placed in the instrument cabinet.

The instruments required for an operation vary greatly according to the nature of the operation and the ideas of the surgeon. The following is suggested as a basic outfit for ordinary operations (others may be added as desired): 2 scalpels; 3 scissors (1 curved Mayo, 1 straight Mayo and 1 blunt for suture scissors); 2 plain thumb forceps; 2 rat-toothed thumb forceps; 10 small straight hæmostats; 10 curved Kelly hæmostats; 8 Allis intestinal forceps; 6 Babcock intestinal forceps; 6 large Oschner straight forceps; 12 towel clips; 2 large retractors; 2 small retractors; 1 grooved director and tongue tie; 1 silver probe; 1 blunt dissector; 3 needle holders; needle kit containing all types of needles (straight intestinal, straight skin, curved cutting, curved intestinal, fascia and muscle needles); plain and chromic gut; assorted glass syringes and hypodermic needles; 3 medicine glasses; and skin clips and forceps or silkworm gut for the skin.

Operating personnel.

In the Navy this consists of the operating surgeon and the medical officers who assist him, the operating-room nurse, the anæsthetist, and two or more hospital corpsmen.

The operating surgeon is in general charge. He is responsible for the patient's life and for the successful outcome of the operation. He is held accountable for all mistakes and accidents, no matter whose the fault may be, that may cause unfavorable outcome.

To the operating-room nurse is delegated the authority necessary for the routine administration of the operating suite. This involves numerous details such as the care and accounting for all property, cleanliness, sterilization, preparation for operations, and supervision and instruction of hospital corpsmen.

The anæsthetist is usually a nurse who has had special training in this branch. She is responsible to the operating surgeon for the general condition of the patient during the administration of a general anæsthetic.

Since local and spinal anæsthesia have become so popular, many surgeons prefer to be their own anæsthetists. The operating-room nurse, in case no regular anæsthetist is assigned, sits at the patient's head during the operation and keeps a record at frequent intervals of the blood pressure, pulse and respirations.

The hospital corpsmen are detailed to the operating room for the purpose of instruction and training so that they will be capable of running an operating room aboard ship. The principal characteristics of a good operating-room hospital corpsman are dependability, faithfulness in the most minute details of his work, and an even temper which will enable him to work quickly and accurately in emergencies, intelligence to understand the reason for everything he does, and a devotion to the welfare of the patient.

PREPARATION FOR OPERATION.

Each one of the *operating room personnel* removes his outer clothes, puts on his operating clothes, and then proceeds to the scrub-up room. Here the hands and forearms are scrubbed for 15 minutes with hot water and green soap and rinsed and soaked in 70 per cent alcohol. This washing should be done in a

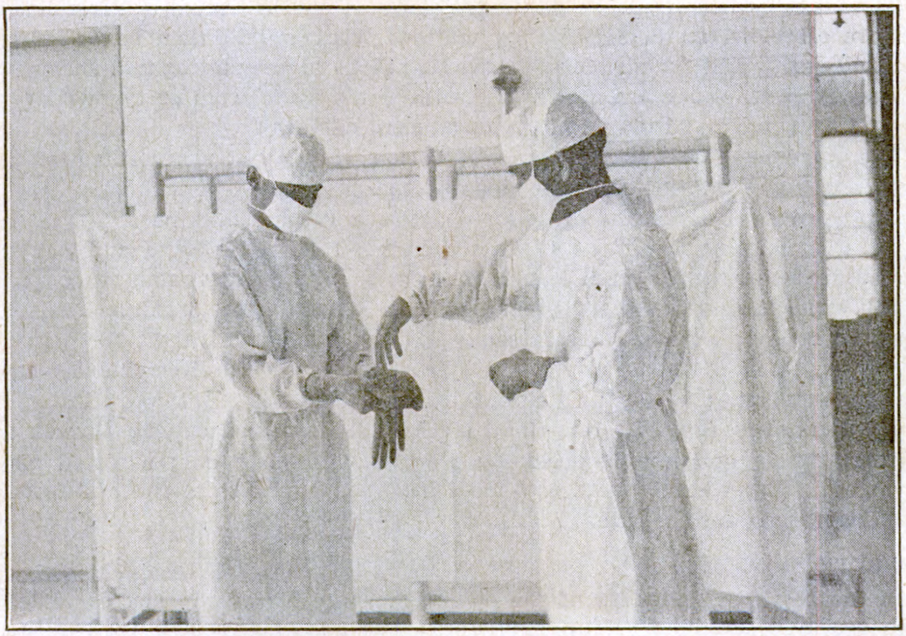

FIGURE 118.—Holding rubber glove for another with palm and thumb of glove turned toward the one who is to wear it.

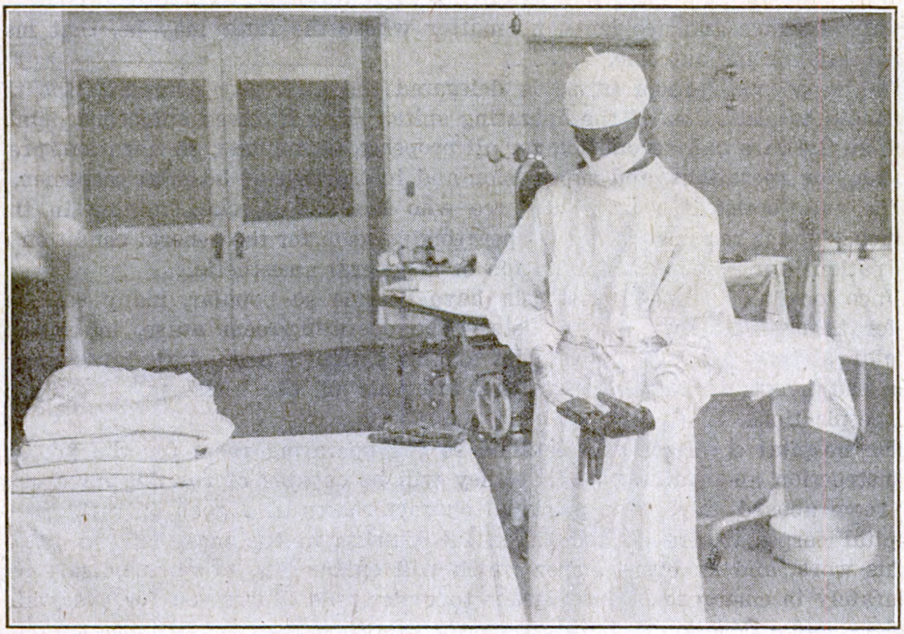

FIGURE 119.—Putting on second rubber glove, with gloved fingers inside the cuff so that they do not touch the ungloved hand.

methodical way so that each side of the fingers and every part of the hands and forearms is scrubbed thoroughly. It is essential that persons engaged in surgical work keep their nails short and clean. No special cleaning of the nails is necessary or desirable while scrubbing for an operation, because this is likely to bring to the surface microörganisms which would otherwise remain harmlessly buried in the tissue beneath the nails. After scrubbing and rinsing in alcohol, the surgeon enters the operating room where he is handed a hand towel with which he dries only his hands, leaving his forearms untouched by the towel. He then puts on a sterile gown and sterile rubber gloves. (Figs. 118 and 119). When fully prepared as above, and while waiting for the start of the operation, the surgeon and his assistants must hold their hands above their waist. If the wait is long, the hands should be covered with a sterile towel.

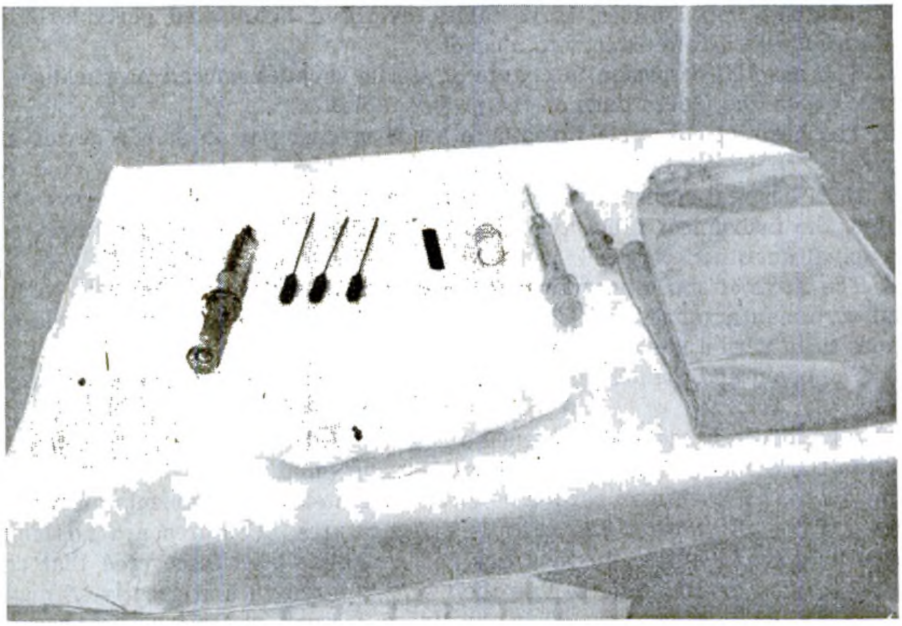

FIGURE 120.—Spinal anæsthesia table.

The *field of operation* is shaved before the patient enters the operating room, though sometimes this is done in the operating room. If a general anæsthetic is used the skin preparation is done after the patient is unconscious. With spinal anæsthesia the field is prepared after the anæsthesia is given. With local or block anæsthesia the field is prepared before the injection of the anæsthetic is given.

If a spinal anæsthetic is used special material and apparatus are necessary which should be laid out on a table as shown in figure 120. The spinal kit consists of the following articles: 2 5-cc hypodermic syringes; 1 2-cc hypodermic syringe; 3 spinal needles; 2 hypodermic needles; 1 mixing needle; 1 ampule saw; 1 sacral sheet; sponges, etc.; 150, 200, or 300 milligrams of novocaine crystals may be used, the desired amount being designated by the operating surgeon. After the spinal injection the table is tilted with the patient's head lowered at about a 10° angle.

There are many ways of preparing the skin. A simple and very satisfactory one is to scrub the skin with a gauze "prep" sponge wet with ether to remove grease and moisture, and then paint the skin thoroughly with tincture of

merthiolate, and allow to dry. After the merthiolate is completely dry paint the skin with a second coat, beginning in the middle of the field and progressing outward to the edges of the previous coat. The field should then be draped with sterile towels and sheets, so that only the prepared skin is exposed. Other common disinfectants used in the Navy for skin preparation are iodine and alcohol, mercurial preparations such as mercurochrome, Scott's solution, etc.

Following is a summary of the routine preparations for an operation:

1. The operating-room nurse, the anæsthetist, and the surgeon are notified as to the time and the nature of the operation.
2. The hospital corpsman in charge of the instruments selects those needed and puts them in the sterilizer along with the necessary utensils.
3. The cutting instruments are placed in the hot-oil sterilizer or in a sterilizing solution.
4. All hands assist in placing the furniture and equipment in proper order, and all glass-topped tables, Mayo tables, overhead lights, and portable lights, are wiped with a towel wet with alcohol.
5. The hospital corpsman in charge of sterile supplies selects the packages of sterile goods and places them on the proper tables.
6. The hospital corpsmen proceed to scrub up and put on sterile gowns and gloves.
7. Both hospital corpsmen drape, with sterile sheets, the table for gowns and gloves, the instrument table, the surgical dressing table, the basin stands, and the spinal anæsthetic table.
8. The trays of sterile instruments are brought in from the sterilizer. A hospital corpsman arranges them in the proper order on the instrument table and drapes them with a sterile towel until they are needed.
9. The basin and utensil set is opened and the contents placed in their proper places.
10. The sterile packages are opened and a hospital corpsman places their contents in the proper place on the surgical dressing table.
11. A hospital corpsman sorts and arranges the extra instruments on the circular table and prepares the sutures and ligatures. (Sutures are no longer placed in a damp towel, but in a dry one, as it has been discovered that continued soaking causes them to lose their tensile strength and greatly increases the danger of contamination. They are dipped in warm water for a few seconds immediately before handing them to the operator).
12. If spinal anæsthesia is to be used, the spinal kit is opened and then prepared by the hospital corpsmen.
13. All tables and stands containing sterile articles are draped with sterile towels or sheets until they are needed.
14. The patient is wheeled into the operating room and the anæsthetic is given.
15. By this time the surgeons and assistants are dressed and scrubbed and ready to be dressed in sterile gowns and gloves by the junior hospital corpsman.
16. The patient's skin is then prepared by the assistant in the manner previously described.
17. The patient is then draped with towels and laparotomy sheets by the assistant and the senior hospital corpsman.
18. The instrument table is rolled into place as well as the double-basin stand.
19. The surgeon and his assistants assume their proper places.
20. The senior hospital corpsman hands the surgeon the scalpel, the incision is made after which the skin knife is discarded and the operation proceeds.

CHAPTER VI

Section 1.—HYGIENE AND SANITATION

COMMUNICABLE DISEASES AND PRACTICAL PREVENTIVE MEDICINE

Preventive medicine may be defined as the branch of medical science which deals with the prevention and control of disease, and includes all hygienic, sanitary, or other measures and practices contributing to that end. *Hygiene* and *sanitation*, often confused with preventive medicine, are really specific fields of prevention of disease. **Hygiene** is the science of health and deals with the proper care of the human body to permit the proper functioning of its various organs. In the broadest sense its object is to "render growth more perfect, decay less rapid, life more vigorous, and death more remote." **Sanitation** deals with the proper care of man's surroundings. *Personal hygiene* pertains to the individual's care of his own body in order that it will function properly.

The practice of preventive medicine is not confined alone to the prevention and control of the diseases which are communicable from man to man, or from animals or insects to man, by means of microörganisms, bacteria, fungi, or minute animal parasites, but to all diseases with which man is affected. The subject thus includes all other fields of medical, surgical, physical, or sociological activity which aid, first, to prevent disease and second, to control its spread.

In the practice of preventive medicine it is necessary to know the cause, the nature, and in what manner man contracts a disease before such diseases may be controlled. The science which deals with determining, describing, and explaining the distribution of disease and variations of type is known as *epidemiology*.

While Hippocrates, who lived in the fifth century B. C., stressed the value of a hygienic mode of life, preventive medicine as a science made slow progress until Jenner's discovery in 1790 of vaccination as a preventive against smallpox. Another lull ensued until Pasteur's discoveries between 1857 and 1882 regarding bacteria as a cause of disease and the value of vaccines and "viruses." Then followed a veritable "germ hunt" by many investigators, with the result that in a remarkably short time not only the cause, but usually the mode of transmission, and hence the means of prevention, of many diseases were discovered.

Communicable diseases are constantly decreasing, and today there are means for the control of many that formerly were prone to occur in epidemic form during mobilization. By environmental sanitation and immunization intestinal diseases can be satisfactorily controlled. Insect-borne diseases can be practically eliminated from a station by attacking the insect, or parasite in the host or both. Smallpox can be controlled by vaccination with cowpox. The incidence of venereal diseases can be greatly reduced by use of immediate and thorough prophylaxis. Adequate control measures for the prevention of certain of the upper respiratory diseases, however, remain to be discovered.

The control of communicable diseases is a problem with which medical officers and hospital corpsmen have to deal constantly. Therefore, the communicable diseases which are most likely to attack the personnel of the Navy will be dealt with in detail. Before considering such diseases separately, the definitions of terms used in connection therewith as recommended by the American Public Health Association, will be given.

Source of infection.—Most of the communicable diseases to which man is susceptible are peculiar to and spread by him. Lower animals are the source of some infections, such as plague, trichinosis, tape worms, etc.

Modes of transmission.—These may be classified in the following general groups:

(*a*) Contact: 1. *Mouth spray or droplet infection.*—In talking, coughing, or sneezing, persons emit from the mouth and nose a fine spray which contains the microörganisms harbored in the mouth, nasopharynx, and respiratory passages. The droplets will remain suspended in the air for varying lengths of time and air currents may distribute them short distances. The radius of droplet infection without air current is 6 or 8 feet; 2. *Hands and fingers* contaminated with infected secretions are unquestionably the most important agencies in contact infection. They may infect directly or indirectly; and 3. *Direct approximation of body surfaces* of two individuals, such as that occurring during kissing or sexual intercourse.

(*b*) Foods, including water and ice, milk and dairy products, meat and shellfish, and vegetables.

(*c*) Insects, by mechanical and biological transmission.

(*d*) Soil.

(*e*) Fomites. Linens, dishes, etc., used by the infected person and contaminated with infected discharges.

Carrier.—A person who, without symptoms of a communicable disease, harbors and disseminates the specific infectious agent of the disease.

Cleaning.—This term signifies the removal by scrubbing and washing, as with hot water, soap, and washing soda, of organic matter on which and in which bacteria may find favorable conditions for prolonging life and virulence; also the removal by the same means of bacteria adherent to surfaces.

Contact.—A "contact" is any person or animal known to have been sufficiently near to an infected person or animal to have been presumably exposed to the transfer of infectious material directly or by articles freshly soiled by such material.

Delousing.—By delousing is meant the process by which a person and his personal apparel are treated so that neither the adults nor the eggs of the varieties of lice that infest man survive.

Disinfection.—By this is meant the destroying of the vitality of pathogenic microörganisms by chemical or physical means. When the word *concurrent* is used as qualifying disinfection, it indicates the application of disinfection

immediately after the discharge from the body of an infected person of infectious material or the soiling of articles with such infectious discharges. When the word *terminal* is used as qualifying disinfection, it indicates the process of rendering the personal clothing and immediate physical environment of the patient free from the possibility of conveying the infection to others at the time when the patient is no longer a source of infection.

Disinfesting.—By disinfesting is meant any process, such as the use of dry or moist heat, gaseous agents, poisoned food, trapping, etc., by which insects and animals known to be capable of conveying or transmitting infection may be destroyed.

Filtrable virus.—The term "filtrable virus" as defining the etiological agent of certain diseases is used in the sense of a causal agent differentiated from other kinds of infectious agents such as bacteria, protozoa, etc. Many of these filtrable viruses can be grown *in vitro* in the presence of living susceptible cells, and such cultures will produce regularly typical diseases in animals and in man. The term "filtrable virus" has a significance comparable to that of bacterium, spirochæte, or protozoon and is as definite a description of an etiological agent as is the statement that the typhoid bacillus causes typhoid fever. The idea conveyed by the statement that a filtrable virus is the etiological agent is that the cause of this disease is known, even though present knowledge does not permit further precision in distinguishing among filtrable viruses except by reference to the name of the disease produced by each.

Fumigation.—By fumigation is meant a process by which the destruction of insects, as mosquitoes and body lice, and of animals, as rats, is accomplished by the employment of gaseous agents.

Incubation period.—The period between the time a person is first infected with a communicable disease until the first clinical symptoms appear is known as the incubation period.

Isolation.—By isolation is meant the separating of persons suffering from a communicable disease, or carriers of the infectious organism, from other persons, in such places and under such conditions as will prevent the direct or indirect conveyance of the infectious agents to susceptible persons.

Quarantine.—By quarantine is meant the limitation of freedom of movement of persons or animals who have been exposed to communicable diseases for a period of time equal to the longest usual incubation period of the disease to which they have been exposed.

Renovation.—By renovation is meant, in addition to cleansing, such treatment of the walls, floors, and ceilings of rooms or houses as may be necessary to place the premises in a satisfactory sanitary condition.

Report of a disease.—By "report of a disease" is meant the notification sent to the health authorities, and, in the case of communicable diseases in animals, also to the respective departments of agriculture, who have immediate jurisdiction, that a case of communicable disease exists in a specified person or animal at a given address.

Susceptibles.—A susceptible is a person or animal who is not known to be immune to the particular communicable disease in question by natural or artificial means.

Immunity.

Because of the part it plays in the control of communicable diseases it is necessary to briefly discuss the defense mechanism against disease that is possessed by the body and is known as immunity.

Although the living body of man may serve as a source of food and as a host for the reproduction and growth of disease-producing microörganisms, or bacteria, it does not willingly or passively do so. Instead, the body resists the entrance of such bacteria and if, in spite of that resistance, entrance is gained, then the body attempts to prevent their reproduction and growth or to destroy them.

Before microörganisms can produce disease they must invade or break through the physiological exterior of the body, or enter through breaks therein. The physiological exterior of the body consists of the skin and the mucous membranes of all passages or tracts leading into and away from the body, e. g., the gastro-intestinal, genito-urinary, and respiratory tracts, etc.

Certain microörganisms, known as parasitic microörganisms or parasites, live on the physiological exterior of the body and under ordinary conditions do not produce disease, while others, known as pathogenic bacteria, possess the power to produce disease. Those which cause the communicable diseases are said to be specific because they can cause only their own disease. Thus the typhoid bacillus can only cause typhoid fever; the diphtheria bacillus alone can cause diphtheria, etc.

The power of bacteria to produce disease is known as *virulence.* This virulence or disease-producing power is increased by suitable food, moisture, and temperature, such as are found in the human body, also by the absence of light and the presence or absence of light and the presence or absence of oxygen for ærobic and anærobic bacteria respectively. The virulence is decreased by the absence or diminution of the above favorable conditions.

The virulence of a bacterium tends to increase under conditions of direct transmission until the maximum virulence is reached, after which it tends to become lessened. Thus many outbreaks have their origin in cases of diseases so mild or atypical as to remain unrecognized. The infected persons go about their work or diversions in contact with many people, handle milk, food, etc., disseminating the infective microörganisms which increase in virulence as a result of the direct transmission.

The body is protected against the invasion of disease-producing bacteria through: 1. The physical barrier or wall afforded by the coverings of the body, its physiological exterior; and 2. Through the action of the secretions of various glands connected with the physiological exterior of the body such as the saliva, gastric juices, perspiration, etc., which wash away the microörganisms, and in many cases kill them.

After the body has been invaded by pathogenic bacteria it protects itself against infection through: 1. The action of antibodies; and 2. Phagocytosis.

In the blood, as explained in the chapter on Anatomy and Physiology, the lymph, and other secretions of the body, and in the tissue cells are substances that together constitute the defense mechanism that acts to prevent the growth of or to destroy invading bacteria.

When microörganisms or their products (toxins) invade, or are injected into the body, the cells of the body are stimulated to produce *antibodies* (p. 32) which fight the invading microörganisms. To have antibodies on hand, so that one will not "catch" certain diseases when exposed to them, the body is inoculated with the vaccines, viruses and toxins, examples of which are typhoid vaccine, cowpox virus, diphtheria toxin-antitoxin mixture. The antibodies formed against a microörganism or its product act only against that particular type of microörganism and prevent only the disease it causes. When a person is infected or exposed to certain communicable diseases, diphtheria for example, a serum containing the specific antibodies which have been produced usually in

the body of a horse is injected into the body to assist in fighting the invading microörganisms, or give an immediate supply of antibodies to prevent those exposed from "catching" the disease. This is necessary because it takes a longer period for the body to form sufficient antibodies to protect itself, either when the person is infected or exposed to the disease.

Phagocytosis is the ability of the white blood cells of the body, particularly the polymorphonuclears, to engulf and destroy the invading microörganisms. In phagocytosis, which is usually associated with inflammation as in a boil or acute appendicitis, there is an increase in the number of white blood cells. The phagocytes and antibodies work in conjunction with each other, especially where inflammation also is present, as in epidemic meningitis (cerebrospinal fever).

From the foregoing it will be seen that, in short, immunity is the ability of the body to ward off disease. It is that power which prevents the gaining of a foothold by disease-producing organisms in the animal body, or which neutralizes their harmful products or destroys the parasites. Its effectiveness depends upon two main factors—the power of resistance of the human body and the aggressiveness or virulence of the invading organisms. Immunity may be *inherent* or *acquired*. *Inherent immunity* is present from birth and is represented best by the immunity of certain animals to specific infections. It is of theoretical interest but of little practical value in diseases of human beings. *Acquired immunity* is that which results from an attack of a disease, called naturally acquired immunity; or from inoculation of the individual with killed specific organisms or their products and known as artificially acquired immunity. Not all diseases confer immunity by their attack, nor is it possible to produce artificial immunity to all diseases.

Artificially acquired immunity may be *active* or *passive*. When the body is infected by disease, or when the causative organisms of a disease are injected into the body, substances are produced that combat that disease, leading to cure and in some cases to the production of prolonged immunity to that disease. The agents that combat the disease are the previously mentioned antibodies, and if antibodies against a specific disease are produced in the body the immunity is known as *active immunity*. When antibodies are produced in one animal and the serum of that animal is injected into another to produce immunity it is known as *passive immunity* because the cells of the second individual played no part in the formation of the antibodies.

The serums used to produce passive immunity are made by giving repeated injections of the specific causative bacteria or their soluble toxins into animals, horses commonly being employed. The animal becomes immune, and its serum contains specific antibodies, which are collected by bleeding the animal and separating the serum. This serum when injected into man or another animal will afford protection against that disease, but no other.

The use of these serums, especially those from the horse, is frequently followed by annoying symptoms and occasionally by severe or even fatal reactions. The syndrome spoken of as *serum sickness* may appear within a day or two of the injection but more often after about 8 or 10 days. The patient usually complains of headaches, fever, joint and muscle pains, œdema, and particularly of various skin eruptions usually urticarial or erythematous in character. Serum sickness is due to foreign proteins in the serum and has nothing to do with the antitoxin. Most of these mild attacks of serum sickness clear up with rest, mild skin lotions and catharsis. Epinephrine will very often relieve the urticaria.

Anaphylactic shock, under certain circumstances, occurs a few minutes after the injection and may be fatal. This complication is characterized by rest-

lessness, anxiety, dyspnœa, cyanosis, unconsciousness, and œdema. *Anaphylaxis* means that the patient is *hypersusceptible* to that serum and does not indicate any inherent poisonous property in the antitoxin. How an individual becomes hypersensitive in these cases is not always clear. A previous injection of horse serum or a hereditary transmission may account for it.

Before administering serum it is necessary to inquire of the patient whether he has had previous injections or has suffered from asthma. In order to prevent anaphylactic shock, all patients should be given an injection of 1/50 cc of serum subcutaneously as a test for hypersensitivity. When this test is positive the procedure for desensitization described on p. 485 should be followed.

Immunity to certain diseases seems to increase with age, and under ordinary conditions adults possess a marked immunity to the so-called "children's disease," such as diphtheria, scarlet fever, etc.

Susceptibility to disease is just the opposite of immunity and means a special liability to contract certain diseases. It may be natural and is greatly increased by overwork, overstrain or worry, inadequate rest or sleep, improper environment, lack of fresh air and sunlight, exposure to wet and cold, insufficient and improper food, excesses in eating and the use of alcohol, disease, injury or operations, and excesses of any kind.

This is well illustrated by the seasonal incidence of "colds," pneumonia, and other respiratory diseases. These diseases are rare during the summer and early autumn when people are much in the open (with little close contact) and get plenty of sunshine (ultraviolet rays), and also eat an abundance of fresh vegetables and fruits which furnish vitamins, mineral salts, and roughage. Likewise, they take more exercise than in winter and are not exposed to wet and cold conditions. With the coming of winter as these favorable conditions decrease the respiratory diseases increase progressively until favorable conditions arrive again in the spring.

Different organs and tissues of the body appear to possess varying immunity against or susceptibility to different microörganisms. In other words, certain microörganisms always select some organ or tissue in the body where they set up their infection. At this site toxins, or poisons, are produced which, when circulated throughout the body, cause general symptoms or effects. For example the meningococcus is thought to enter the body through breaks in the mucous membrane of the nose and throat, and is carried by the blood to the membranes of the brain and spinal cord where it causes cerebrospinal fever.

These facts are applicable to the occurrence of epidemics or outbreaks of disease. To have an epidemic there first must be present a highly virulent microörganism; then a sufficient number of persons who are susceptible to that particular microörganism. The spread of the disease is influenced by whether or not susceptibles come in contact with the infective microörganism. The best means to prevent this and hence control the spread of epidemics is to detect new cases as early as possible, isolate them immediately, and practice rigid concurrent disinfection to prevent dissemination of the infective microörganisms. Early treatment also results in a fewer number of deaths. In some diseases the persons who have been in contact with the infected one are quarantined for the normal incubation period of the disease.

For these reasons it is necessary to be constantly on the alert to detect sick persons at the earliest possible moment, as they may be "coming down" with highly communicable diseases.

It has been proposed that the term "mass immunity" be used to account for the decreasing number of communicable diseases transmitted by the nose and

mouth discharges. In explanation it is suggested that under conditions of close association where the hygienic and sanitary conditions are good and the general population is healthy, an immunity of varying degree to such diseases is built up as a result of exposure to pathogenic microörganisms of low virulence or disease-producing power. In other words, healthy people living under good sanitary conditions are benefited by the exchange of microörganisms in the droplet spray incident to close association such as is met with in the military and naval services and in city life. On the other hand, epidemics are bound to occur among overcrowded populations living under insanitary conditions.

Food and its relation to health and disease.

While food usually is considered in its relation to the maintenance of bodily health and efficiency it is sometimes injurious to health. Animal foods convey infections or have properties injurious to health more frequently than those obtained from plants, and meat and milk are the principal offenders.

Food may affect health as a result of: 1. Natural poisons contained in it, as some mushrooms, some fish, etc.; 2. Animal parasites or their eggs or larvæ contained in or conveyed by foods; 3. Bacteria conveyed by both animal and vegetable foods, as tubercle bacilli, typhoid bacilli, streptococci, etc.; 4. Toxins developing in foods as a result of bacterial growth, as botulism; 5. Special poisons contained in foods, as solanin in sprouted potatoes; 6. Poisons accidentally or purposely added, as arsenic, lead, acids, insect powders, etc.; 7. Amount, too little or too much; 8. Composition, an unbalanced diet; 9. Faulty digestion or disturbances of metabolism; and 10. Idiosyncrasy to certain foods.

Food poisoning can cause acute attacks of illness in more men in a short time than any other condition. The term "food poisoning" is conventionally divided into two groups, *food infection* and *food intoxication*. Food infection is usually caused by a specific group of organisms, namely the Salmonella group but occasionally the Dysentery group. Food intoxication is due to a specific toxin produced outside the body, for example the Clostridium botulinum. Other organisms cause food intoxication by producing toxins, the exact nature of which is imperfectly understood. These toxins are formed under suitable conditions by staphylococci, streptococci, coliform, proteus, and possibly salmonella organisms.

The consumption of unwholesome food may also give rise to diverse conditions due to inherently poisonous substances, e. g., toad stools, hemlock, certain fruits, and fish which are poisonous; food containing poisonous substances such as arsenic, lead, or other heavy metals; and foods for which the individual has an idiosyncrasy.

Food infection is characterized by a sudden onset with headache, followed by nausea, vomiting, diarrhœa, abdominal pain or distress, prostration and sometimes fever, and commencing from 1 to 24 hours after ingestion of food. The causative organism may be revealed by examination of the vomitus and fæces.

The great majority of outbreaks are caused by meat or meat mixtures. The meat may come from an animal infected during life with a specific organism; or it may come from a healthy animal and be infected during the process of slaughtering and handling. Such sources of infections are best controlled by meat inspectors at slaughter houses. Food handlers with hands not thoroughly washed after leaving the toilet, hands and arms infected with boils and other sores are frequent means of conveying contamination to food. Food may also be infected by flies, cockroaches, rats, mice, and polluted water when used in cooking and preparation of food.

Foods which most often cause food poisoning are mixtures with meat as a basis, such as hash, meat or fowl loaf, and pie; meat, crab, lobster, and chicken salads; hamburger steak; and cold sliced meat. Veal mixtures are a frequent cause. Milk and milk products also have been reported as causes of outbreaks.

Meat mixtures that have caused trouble have the following in common: They are cooked, then handled in preparation, and often allowed to stand in a warm place several hours; in some instances over night. If they have been infected with one of the causative organisms, it may be readily seen that with moisture, a good protein food supply, and warmth, there is every desirable condition present for a large growth of bacteria and the production of much toxin.

The filling of cream puffs, cream pies, and custards and various sauces made from milk and cream have been the cause of outbreaks.

It is important to remember that the organisms which cause food infection do not necessarily cause any alteration from the normal appearance, odor, or taste of the food. A classic example of this occurred in connection with an outbreak in Ghent, Belgium. A meat inspector was so certain that the suspected meat had no connection with the trouble that he ate three slices to demonstrate their harmlessness. He suffered a severe attack of gastro-enteritis and died five days later. Bacterium enteritidis was isolated from his viscera at autopsy.

The treatment is mainly eliminative, symptomatic, and supportive. Elimination is largely effected by the infection through vomiting and diarrhœa. If the number of cases is not too large gastric lavage can be performed, followed by a saline purge. Rest and Nature usually effect a cure. While the symptoms are sometimes alarming, the fact should be kept in mind that the mortality is only between 1 and 2 per cent.

The preventive measures are plainly indicated by the sources of the infection. The ante-mortem sources can be eliminated only by a rigid inspection of animals before slaughtering. Post-mortem sources can be prevented by careful inspection of the slaughtered carcasses for localized infection and the elimination of any suspected meat until it is proved safe by bacteriological examination; also, by disinfecting the hands, tools, and other objects and surfaces which have been contaminated by infected carcasses in the slaughter house.

On board ship, no food, especially meat mixtures, should be prepared and then set aside to be served at a subsequent meal. The time between the preparation and serving of the food should be reduced to the minimum. If it becomes necessary to hold over any food, it should be put in a cold refrigerator as soon as possible and kept cold until it is to be served or prepared for serving.

A high standard of sanitation in the galley and butcher's shop is very important. The personal hygiene of the cooks and handlers of food should be looked into; particularly, their attention to the important detail of thoroughly washing their hands after visiting the toilet. They should be watched constantly for symptoms of intestinal disturbances and no men allowed to handle or prepare food who are suffering from any degree of diarrhœa.

Immediately after an outbreak occurs effort should be made to get samples of the last meal served so that they can be examined in a laboratory. After the rush of cases has slackened, an epidemiological study of the outbreak should be undertaken. The patients should be questioned regarding the foods eaten and the messes to which they were assigned. Unaffected members of the same mess should be interrogated as to whether they ate the same foods. Men frequently eat the same foods, but because of immunity, eating very small

portions, or an unequal distribution of the infection throughout the food mass, are not affected.

By careful study one can arrive at a fairly accurate idea of the food responsible for the outbreak. If some men were affected yet did not eat the suspected food, that food should be ruled out. Specimens of the urine and fæces from the more severe cases should be collected and sent as soon as possible to the nearest hospital or other clinical laboratory for examination.

Food handlers should be brought under observation for medical and bacteriological examination to determine possible origin, whether from infections of the skin or bowel discharges.

Food intoxication follows the ingestion of food containing toxic substances which have been formed by proliferation of bacteria. The general symptoms of food intoxication, caused by other than the Clostridium botulinum, are similar to those due to food infection, but the time interval of onset is shorter—half an hour to 4 hours—vomiting is more violent, and prostration more severe, there is usualy less fever and recovery is more rapid.

The type of food associated with such outbreaks varies considerably. It usually includes canned or potted meat or fish, pressed tongue, beef, or ham, cheese or milk products.

In outbreaks where demonstrable evidence of Salmonella or dysentery infection is absent the laboratory should endeavor to find the presence of toxins of bacterial origin in the food or organisms capable of forming toxic substances.

Botulism is an acute food intoxication due to the toxin produced by the *Clostridium botulinum* and is characterized chiefly by oculomotor paralysis, weakness, prostration, incoordination, a variety of central nervous system paralyses, and a high case-fatality rate.

The botulism toxin has a strong affinity for the nervous system in animals as well as man. It causes "limber neck" in chickens and turkeys and various types of paralysis in domestic animals.

There are at least four strains of the organism—Types A, B, C, and D. Antitoxins have been prepared from strains A and B by injecting increasing amounts of the toxin into susceptible animals. The antitoxin prepared from the toxin of one strain of the organism will not protect against the toxin produced by the other strain. Types C and D have not been found in the United States and have not been known to cause botulism in man.

The transmission is only by eating food containing the botulinus toxin. In the United States it has been associated with such foods as string beans, cottage cheese, corn, asparagus, peas, and spinach, particularly when the vegetables named were canned at home and the processing temperatures were not high enough to kill the spores. Ripe olives, which have been improperly processed, have been a frequent source of the infection. Fresh foods are seldom, if ever, dangerous in so far as botulism is concerned. Smoked, pickled, and canned, particularly home-canned, foods are the dangerous ones.

There may be some evidence of spoilage about the infected food, but many foods which have produced botulism have been normal in taste, odor, and appearance. It is said that the peculiar butyric acid or rancid butter odor associated with cultures of botulinus is present; this is not always the case, and because of the extreme lethal character of the toxin no suspected food should be tasted. It is not safe to taste "home-canned" foods before they have been thoroughly cooked. Canned goods which show gas formation, either by the presence of gas bubbles or bulged ends of cans, should be destroyed.

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The symptoms usually appear in 24 hours after the particular food has been eaten. This interval may be shortened or lengthened in proportion to the amount of toxin ingested.

The disease is ushered in with a general feeling of indisposition, fatigue, and muscular weakness. There may be headache and dizziness. Gastro-intestinal symptoms are not frequent except in the severe cases, when there may be gastric distress, nausea, vomiting and diarrhœa; these symptoms are transient. Constipation, due to paralysis of peristalsis, is constant.

Disturbances of vision occur early, associated with or followed by difficulty in swallowing and talking. The mouth and throat are dry and the breath offensive. There is a dry ineffectual cough and a bitter taste in the mouth.

The pulse is usually rapid and the temperature subnormal. Respiration at first is not impaired, but later the embarrassment becomes great and death results from paralysis of the respiratory center.

Death may occur in 48 hours after ingesting the poison; usually it occurs within 4 to 8 days; few die after 10 days.

The mortality of botulism is very high and depends upon the amount and virulence of the toxin ingested. The mortality runs from about 60 per cent in some outbreaks to 100 per cent in highly virulent outbreaks.

The table next hereafter, in which Burke and May have tabulated the differences in botulism and food infection, is copied from Practical Bacteriology, Hæmatology, and Animal Parasitology (Stitt, Clough and Clough).

	Botulism	Food infections
Cause	Botulinus toxin	Bacilli of the Salmonella group.
Fever	Not characteristic; temperature usually subnormal.	Characteristic; acute.
Occurring	Mainly in winter	Mainly in summer.
Associated with	Preserved foods	Fresh foods or freshly contaminated foods, usually meat or milk.
Condition of bowels	Constipation; rarely diarrhœa	Diarrhœa; offensive.
Visual disturbances	Double vision; ptosis of lids	Absent.
Abdominal pain	Absent	Present.
Onset	Usually gradual	Sudden.
Incubation period	Variable, usually from 12 hours to several days.	Short, usually from 6 to 12 hours.
Throat	Swallowing difficult	Normal.
Treatment	Antitoxin	Systemic.
Mortality	From 60 to 70 per cent	From 1 to 2 per cent.

The treatment consists of administration of the appropriate antitoxin as soon as botulism is suspected, but do not wait for the diagnosis to be confirmed. Antitoxin should be given to others who ate the same food, even though they have shown no symptoms of botulism. The botulinus toxin is a nerve poison; therefore the antitoxin is of little use after the disease is well advanced.

Until antitoxin can be administered, full physiological doses of morphine should be given. Death results from paralysis of the respiratory center; therefore artificial respiration is often indicated.

The prevention of botulism is in the main a matter of using great care and cleanliness in the preservation of nitrogenous foodstuffs. Fruits and vegetables should be heated to at least a temperature of 120° C. for a period of not less than 10 minutes when they are being preserved in order to kill the botulinus spores. It is not safe to use "home-canned" vegetables for salads, etc., unless they have been cooked after removal from the container. Neither should they be tasted before cooking to detect spoilage.

The average amount of cooking will destroy the toxin, but it will not kill the spores. These may remain alive and, in case the food is set aside for a while, form more toxin. Such foods should be reheated before eaten. Thorough and recent cooking of all food is preventive against botulism.

In commercial canning the food is heated to appropriate temperatures which render the food sterile.

Following an outbreak, effort should be made to obtain specimens of the responsible food and have them examined at the nearest naval hospital or other clinical laboratory. Specimens in sterile containers can be sent to the U. S. Naval Medical School, Washington, D. C., for examination.

While botulism does not occur with great frequency, nevertheless, because of its virulence and high mortality, it is advisable to have a centralized and readily available supply of antitoxin.

The following questionnaire indicates the epidemiological data desired by the Bureau of Medicine and Surgery in cases or outbreaks of food poisoning. A careful study of this questionnaire will not only serve as a basis of an epidemiological study but will also serve as a quiz on the foregoing discussion. The student should ask himself why each question is asked and to what type of food poisoning a positive and negative finding in each instance should point:

"I. What was the character of duty being performed at the time the supposed poisoning occurred?

II. What was the supected food; where and under what circumstances was it eaten?

III. What other foods were eaten during the period when poisoning could have occurred—(within 48 hours for practical purposes)? Discuss menus of meals served.

IV. How long after eating was it before the first indications of illness appeared?

V. Were others made ill at the same time? If so, how many and what was the relationship to this case?

VI. Did any person or persons eat the same food without becoming ill?

VII. Give clinical description of the case not overlooking the following points:

- *a.* What was the first indication of illness?
- *b.* Was the onset sudden?
- *c.* Had there been any previous disease or symptoms?
- *d.* Could this attack have been a relapse or recurrence of any disorder?
- *e.* How long had the patient been ill when first seen by the medical officer?
- *f.* What was the general appearance of the patient?
- *g.* Was there any pain? If so, was it continuous or spasmodic?
- *h.* Was there vomiting? For a short period or continued for a day or more?
- *i.* Was there intestinal colic or abdominal distention?
- *j.* Was there diarrhœa? If so, describe.
- *k.* Was there a chill?
- *l.* Was there any fever? If so, describe.
- *m.* Was there headache? Frontal or occipital?
- *n.* Was there general aching or soreness?
- *o.* Was there prostration? Sudden? Marked?
- *p.* Was the mouth dry? Was there excessive salivary secretion? Was there a continued bitter taste?
- *q.* Were there any ocular symptoms—ptosis, blurring, diplopia, disturbances of accommodation? What was the condition of the pupils and pupillary reflexes?
- *r.* Was there alternate flushing and pallor?
- *s.* What was the pulse rate? Was the pulse persistently rapid or slow? Was it regular or intermittent? What was the blood pressure?
- *t.* What was the rate of respiration per minute? What was the character of the breathing?
- *u.* Was there any skin eruption? If so, describe.

VIII. Was a blood count made? If so, give findings.

IX. Was the urine examined? What were the findings? Was a culture made from the urine?

X. Was any toxicological or bacteriological examination made of the vomitus or stools?

XI. What are the ascertainable facts regarding the purchase, condition, storage, handling, preparation, cooking, and serving of the suspected food?

XII. If canned goods, did the can appear to be in good condition before opening? How long had the can been opened before the contents were used? Were the contents kept cold? Was the food heated or boiled before it was eaten? Was the food served hot or cold? Was there any evidence of spoilage? Give name of brand or manufacturer and necessary data for tracing this shipment.

XIII. Was any of the suspected food obtainable for examination? Was any of it fed to experimental animals and if so, did it make them sick? What laboratory examination was made of the food?

XIV. If suspected food was purchased or eaten at a civilian establishment, and there was reason to supect their methods of handling food, were the local health authorities notified in order to prevent the poisoning of others?

It is requested that any pertinent facts which are not brought out in replies to above questions be added."

Milk is man's most important food and one for which there is no effective substitute. For the suckling of the same species it contains all the elements and vitamins necessary for life. But at the same time it (together with its products, particularly cream) is one of the most frequent means of transmission of such diseases as bovine tuberculosis, typhoid and paratyphoid fevers, diphtheria, scarlet fever, septic sore throat, Malta fever, dysenteries, and diarrhœa.

Milk is a natural culture medium for bacteria; it decomposes readily and is probably the most difficult of all foods to obtain, handle, transport, store and deliver in a clean, fresh, and satisfactory condition. The number of bacteria per cc is the most reliable test to determine its age, purity, and cleanly methods of handling. Milk is graded chiefly on its bacterial content. Today milk is largely consumed in a pasteurized state. All milk for use by naval personnel should be Grade "A" pasteurized milk and delivered in bottles.

Pasteurization is a process by which milk is heated to a degree sufficient to kill harmful microörganisms but with the least possible effect upon the value of milk as a food. There are two recognized methods of commercial pasteurization, the holding method and the flash method.

In the holding method of pasteurization every particle of milk is heated to a temperature of not less than 143½° F. and held at such temperature for not less than 30 minutes in apparatus of approved design and properly operated. The milk is then rapidly cooled to a temperature of 50° F.

In the flash method of pasteurization every particle of milk is heated to a temperature of not less than 160° F. and held for not less than 15 seconds in an apparatus of approved design and then rapidly cooled to a temperature of 50° F.

Pasteurization may cause a slight reduction in the vitamin content of milk but milk need not be used as a principal source of vitamins.

Contamination of milk with disease-producing bacteria is almost always from human sources. The preventive measures are scrupulous cleanliness in production methods, immediate chilling of milk, and keeping it clean and cold until consumed.

The following paragraphs regarding foods and messing are taken from U. S. Navy Regulations and are of particular interest to the hospital corpsman.

"Art. 1320 (2).—A medical officer shall inspect, as to quality, all fresh food purchased for the general mess, and frequently inspect the fruit and other articles of food and drink offered for sale alongside. In localities where night soil is commonly used for fertilizing purposes none of the vegetables ordinarily eaten uncooked shall be permitted on board; and in infected ports no fresh milk, bottled water or fruits shall be allowed.

"(3).—When possible a junior medical officer and one or more petty officers shall be present when meals are served out at the galley; they shall report if there is any cause for complaint as to the quantity and quality of the food.

"(4).—The commanding officer shall establish hours for messing, having due regard for the duties of the ship and the health of the crew. The crew shall not be disturbed during meal hours when it can be avoided. The practice of conducting visitors through the messing space during meal hours shall be discouraged.

"(5).—The commanding officer shall see that all cooking and mess utensils are kept clean; that the food is wholesome and well cooked. Only pure water, distilled when practicable, shall be allowed for drinking and culinary purposes, and no water shall be issued for drinking until it has been examined and approved by the medical officer."

Likewise all cooks, mess cooks, and other food handlers should be frequently examined for the presence of disease.

The discussion of communicable diseases that follows was published by the United States Public Health Service in pamphlet form entitled "The Control of Communicable Diseases." A few of the diseases in that publication have been omitted, but in no instance has the sense of the contents been modified.

GROUP I. DISEASES TRANSMITTED BY DISCHARGES FROM THE MOUTH AND NOSE

Cerebrospinal fever.
Diphtheria.
German measles.
Influenza.
Measles.
Mumps.
Pneumonia.
Scarlet fever.
Septic sore throat.
Tuberculosis.
Whooping cough.
Others, not here discussed:
  Leprosy.
  Poliomyelitis.
  Tonsillitis, acute follicular.
  Vincent's angina.

Cerebrospinal fever.

1. *Recognition of the disease.*—An acute infectious disease with sudden onset, fever, headache, nausea, rigidity of neck, and in epidemics not infrequently petechial spots on the skin. The specific microörganism in one of its several types may in some cases be found in the early stages by blood culture, and usually during the course of the disease in the spinal fluid, and in the discharges of the retronasal surfaces. The disease occurs in epidemic and sporadic manner.
2. *Etiological agent.*—**Neisseria intracellularis** (*Diplococcus intracellularis meningitidis; meningococcus*).
3. *Source of infection.*—Discharges from the nose and mouth of infected persons. Clinically recovered cases, and healthy persons not known to have had the disease but recently in contact with cases or other carriers may act as carriers and are commonly found, especially during epidemics. Such healthy carriers are found independent of epidemic prevalence of the disease, even up to 5 to 10 per cent of a general population.
4. *Mode of transmission.*—By direct contact with infected persons and carriers and indirectly by contact with articles freshly soiled with the nasal and mouth discharges of such persons.
5. *Incubation period.*—Two to ten days, commonly seven; tends to be short in epidemics; in rare instances the period may be longer when a carrier develops the disease.
6. *Period of communicability.*—During the clinical course of the disease and until the specific microörganism is no longer present in the nasal and mouth discharges of the patient, about 2 weeks. The same applies to healthy carriers so far as affects persistence of infectious discharges. Readily communicable in crowded living conditions among persons of lowered resistance.
7. *Susceptibility and immunity.*—Susceptibility is limited. Acquired immunity from having had the disease, apart from immediate clinical relapses, may be of long duration but is uncertain. There is no artificial immunity. Re-

sistance to infection appears to be low when those exposed to crowded conditions of living are also fatigued and ill fed

8. *Prevalence.*—Usually low incidence of sporadic cases. Within a community in epidemics at long but irregular intervals. The cases are mostly in children under 10 years of age and in young adults, but occur at all ages. Local epidemics commonly related to chronic or emergency overcrowding of living quarters, as in ships, barracks, and lodging houses or slums, and usually in the winter or spring. No limitations in geographical distribution.
9. *Methods of control:*
   - A. The infected individual, contacts, and environment:
     1. Recognition of the disease and reporting: Clinical symptoms confirmed by the microscopic and bacteriological examination of the spinal fluid, and by bacteriological examination of nasal and pharyngeal secretions.
     2. Isolation of infected persons until 14 days after onset of the disease or until negative swabs are obtained from the naso-pharynx.
     3. Concurrent disinfection: Of discharges from the nose and mouth or articles soiled therewith.
     4. Terminal disinfection: Cleaning.
     5. Quarantine: None.
     6. Immunization: None.
     7. Investigation of source of infection: Impracticable.
   - B. General measures:
     1. Education as to personal cleanliness and necessity of avoiding contact and droplet infection.
     2. Prevention of overcrowding such as is common in living quarters, transportation conveyances, working places, and especially in barracks, camps, and ships.
   - C. Epidemic measures:
     1. Increase the separation of individuals and the ventilation in living and sleeping quarters for such groups of people as are especially exposed to infection because of their occupation or some necessity of living conditions. Chilling, bodily fatigue, and strain should be minimized for those especially exposed to infection.

Diphtheria.

1. *Recognition of the disease.*—An acute febrile infection, generally of the air passages, especially of tonsils, throat, and nose, marked by a patch or patches of dirty white and grayish membrane, from which cultures of the diphtheria bacillus may be obtained. Cases of diphtheritic infection in infants are often missed because of the lack of definite local symptoms.
2. *Etiological agent.*—**Corynebacterium diphtheriæ** (*Bacillus diphtheriæ; the Klebs-Loeffler bacillus*).
3. *Source of infection.*—Discharges from diphtheritic lesions of nose, throat, conjunctiva, vagina, and wound surfaces. Secretions from the nose and throat of carriers of the bacillus.
4. *Mode of transmission.*—Directly by personal contact, indirectly by articles freshly soiled with discharges, or through infected milk or milk products.
5. *Incubation period.*—Usually 2 to 5 days, occasionally longer if the carrier state precedes the development of clinical symptoms.
6. *Period of communicability.*—Variable, until virulent baccilli have disappeared from the secretions and the lesions. Usually 2 weeks or less, seldom over 4 weeks. In exceptional cases virulent bacilli remain in the throat and discharges from 2 to 6 months.

7. *Susceptibility and immunity.*—Infants born of mothers with an established immunity are relatively immune for the first 6 months of life. By the ninth month of life this passive congenital immunity has been lost in a high percentage of infants. Subsequently children and adults develop immunity apparently in approximate proportion to their contact with associates who carry the diphtheria bacillus with or without exposure to persons with recognized attacks of the disease. It is usual to find about half of the children of school age and three-quarters of adults in large cities immune. Such accidental immunity is less frequent among rural and small-town populations. Passive temporary immunity (10 days to 3 weeks) and active immunity of commonly permanent duration can be developed artificially. Recovery from attack of the disease, especially if with the aid of therapeutic diphtheria antitoxin, is not necessarily followed by active immunity.
8. *Prevalence.*—Endemic and epidemic. Two-thirds or more of the cases are in children under 10 years of age and two-thirds or more of the deaths occur in children under 5 years of age. More common in temperate zone than elsewhere, and in fall and winter months. Local increased prevalence may occur in irregular cycles of 4- to 8-year intervals. Reduction in incidence, death rate, and case fatality rate has been progressive and marked in the past 30 years.
9. *Methods of control:*

A. The infected individual, contacts, and environment:

1. Recognition of the disease and reporting: By clinical symptoms with confirmation by bacteriological examination of discharges.
2. Isolation: Until 2 cultures from the throat and 2 from the nose, taken not less than 24 hours apart, fail to show the presence of diphtheria bacilli. Isolation may be terminated if the microörganism reported as morphologically "positive" although persistently present, proves to be an avirulent form. Where termination by culture is impracticable, cases may be terminated with fair safety as a rule 16 days after onset of the disease. A virulence test should be made in any case where positive throat cultures are reported 3 weeks or longer after onset of the disease.
3. Concurrent disinfection of all articles which have been in contact with the patient, and all articles soiled by discharges of the patient.
4. Terminal disinfection: At the end of the illness, thorough airing and sunning of the sick room, with cleaning or renovation.
5. Quarantine: All intimate contacts until shown by bacteriological examination not to be carriers.
6. Immunization: Passive immunization with antitoxin is rarely necessary for exposed persons over 5 years of age, for whose protection daily examination by a physician or nurse suffices. Infants and young children exposed to diphtheria in the family should receive a prophylactic dose of antitoxin without prior Schick testing, unless they are already known to the physician to be immune.
7. Investigation of source of infection: In unreported cases, in carriers, and milk.

B. General measures:

1. Active immunization of all children, without prior Schick testing, at the age of 6 months, with a diphtheria toxoid. This same

procedure should be applied to all children at or below 6 years of age if immunization has been neglected in infancy.

2. Older children, and adults especially exposed, including teachers, nurses, and physicians found to be Schick-positive should be actively immunized. In order to minimize local and constitutional reactions in members of these groups, it is desirable to carry out a preliminary "toxoid reaction test", nonreactors to receive toxoid, and reactors toxin-antitoxin (goat) in 2 or 3 inoculations or suitably diluted toxoid.
3. Pasteurization of milk supply.
4. Educational measures to inform the public, and particularly the parents of little children, of the advantages of toxoid immunization in infancy.

German measles (Rubella).

1. *Recognition of the disease.*—A febrile infection in epidemics, characterized by a polymorphous rash, sometimes resembling that of measles, sometimes that of scarlet fever, and sometimes of both at the same time; few or no constitutional symptoms but almost always enlargement of post-auricular, sub-occipital and cervical, and occasionally of other, lymph nodes. Usually absence of leucocytosis.
2. *Etiological agent.*—Unknown.
3. *Source of infection.*—Secretions of the mouth and possibly of the nose.
4. *Mode of transmission.*—By direct contact with the patient or with articles freshly soiled with the discharges from the nose or throat of the patient.
5. *Incubation period.*—From 14 to 21 days; usually about 16 days.
6. *Period of communicability.*—From onset of catarrhal symptoms for at least 4 days, but not more than 7; the exact period is undetermined. Highly communicable.
7. *Susceptibility and immunity.*—Susceptibility is general among young children. An attack usually confers permanent immunity.
8. *Prevalence.*—Epidemic in expression, occurring mostly in childhood, but more in adults than is the case with measles. Commoner in urban than in rural communities, and oftener in winter and spring than at other seasons.
9. *Methods of control:*

   A. The infected individual, contacts and environment:

   1. Recognition of the disease and reporting: Clinical symptoms.
   2. Isolation: Separation of the patient from nonimmune children, and exclusion of the patient from school and public places for the period of presumed infectivity. Isolation rarely practicable.
   3. Concurrent disinfection: Discharges from the nose and throat of the patient and articles soiled by discharges.
   4. Terminal disinfection: Airing and cleaning.
   5. Quarantine: None.
   6. Immunization: None.
   7. Investigation of source of infection: Of no importance except to clarify doubts created by clinical difficulty in distinguishing this disease from scarlet fever in its early stages.

   B. General measures: None.

NOTE.—The reason for attempting to control this disease is that it may be confused with scarlet fever during its early stages; each person having symptoms of the disease should therefore be placed under the care of a physician and the case should be reported to the local department of health.

Influenza.

1. *Recognition of the disease.*—Whether occurring in a pandemic, in endemic-epidemic incidence, or as sporadic cases this disease is characterized in its typical form by sudden onset, fever of 1 to 7 days' duration, accompanied by excessive prostration, aches and pains in back and limbs, coryza and bronchitis, and not uncommonly by pneumonia as a complication. During epidemic when such cases occur in large numbers and over a wide area, other cases of less distinctive type are found to be epidemiologically related to typical cases, and in these the diagnosis would not be made without such obvious association. The clinical criteria of influenza are quite indefinite, particularly in absence of widespread prevalence of the disease. Microscopic or other laboratory procedures are of no practical value in determining or excluding the diagnosis of influenza.
2. *Etiological agent.*—A filtrable virus; associated often with various types of bacteria as secondary invaders.
3. *Source of infection.*—Probably discharges from the mouth and nose of infected persons and articles freshly soiled by such discharges.
4. *Mode of transmission.*—Believed to be by direct contact, by droplet infection, or by articles freshly soiled with discharges of the nose and throat of infected persons.
5. *Incubation period.*—Short, usually 24 to 72 hours.
6. *Period of communicability.*—Undetermined; possibly in prodromal as well as in the febrile stage and convalescent stages.
7. *Susceptibility and immunity.*—Susceptibility is not general, for natural resistance or relative immunity appears to protect from one-quarter to three-quarters of persons intimately exposed to the disease even during widespread epidemics. Acquired immunity if it is actually developed by an attack of and recovery from the disease is of short duration (a few months) and of low grade, or perhaps only effective against a certain strain or strains of the virus.
8. *Prevalence.*—Uncertain in pandemic, local epidemic, and sporadic occurrence, by reason of indefinite clinical symptoms. In epidemics may affect up to 50 per cent of the population, especially at age groups between infancy and maturity. Commonly between December and May in North America. Occurs pandemically in cycles with intervals of several decades.
9. *Methods of control:*
   - A. The infected individual, contacts, and environment:
     1. Recognition of the disease and reporting: By clinical symptoms only. Uncertain in interepidemic periods.
     2. Isolation: During acute stage of the disease, especially in severe cases and those complicated by pneumonia.
     3. Concurrent disinfection: Discharges from the nose and throat of the patient.
     4. Terminal disinfection: None.
     5. Quarantine: None, but visiting should be discouraged.
     6. Immunization: None.
     7. Investigation of source of infection: Of no practical value.
   - B. General measures:
     1. During epidemics efforts should be made to reduce opportunities for direct contact infection, as in crowded halls, stores, and street cars. Kissing, the use of common towels, glasses, eating utensils or toilet articles should be avoided. In isolated towns and institutions infection has been delayed and sometimes avoided by

strict exclusion of visitors from already infected communities. The closing of the public, parochial, and private schools has not been effective in checking the spread of infection. The judicious use of masks by nurses and other attendants may prove of value in preventing infection in hospitals. Scrupulous cleanliness of dishes and utensils used in preparing and serving food in public eating places should be required, including the subjection of such articles to disinfection in hot soap suds. In groups which can be brought under daily professional inspection, the isolation of early and suspicious cases of respiratory tract inflammation, particularly when accompanied by a rise in temperature, may delay the spread of the disease. To minimize the severity of the disease, and to protect the patient from secondary infections and thus reduce mortality, patients should go to bed at the beginning of an attack, and not return to work without the approval of their physician.

2. Crowding of beds in hospitals and institutions to accommodate increased numbers of patients and other inmates is to be especially avoided. Increased spacing between beds in wards and dormitories should be carried out to reduce the risk of attack, and of the occurrence of pneumonia.

Measles.

1. *Recognition of the disease.*—Clinical characteristics are fever, catarrhal symptoms in eyes and nose and throat in the prodromal stage, as well as at the height of the disease, an early eruption in the mouth, Koplik spots, later an exanthem and enanthem, and a branny desquamation during convalescence. When the disease is prevalent, or a susceptible child has been exposed to a case of measles, the diagnosis should be suspected on appearance of the fever and catarrhal symptoms, without waiting for confirmatory eruptions, and isolation precautions should be instituted at once.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—Buccal and nasal secretions of an infected individual.
4. *Mode of transmission.*—Directly from person to person; indirectly through articles freshly soiled with the buccal and nasal discharges of an infected individual. The most easily transmitted of the communicable diseases.
5. *Incubation period.*—About 8 to 10 days from date of exposure to onset of fever; 12 to 14 days to appearance of rash; rarely as long as 18 days. When convalescent serum has been used, but too late to prevent infection, the incubation period may be as long as 21 days.
6. *Period of communicability.*—During the period of catarrhal symptoms and until the cessation of abnormal mucous membrane secretions—minimum period of 9 days; from 4 days before to 5 days after the appearance of the rash.
7. *Susceptibility and immunity.*—All persons must be considered susceptible until they have had the disease, except that most babies born of mothers who have had the disease are immune for the first six months of life. Natural immunity may last into adult life in rare instances. Acquired immunity is usual after recovery from an attack. Passive immunity may be established for a few weeks, but not more than 4, by the use of 4 to 10 cc of convalescent measles serum or 20 to 50 cc of whole blood of immunes, or if citrated blood is used, 25 to 60 cc.

8. *Prevalence.*—Universal. Probably 80 to 90 per cent of all persons surviving to the twentieth year of life have had an attack, and rarely does a person go through life without having had measles. Occurs most commonly in children between 5 to 14 years of age, but many cases are in children under 5. Endemic in large population units. In remote or insular groups epidemics occur on contact with a case in a visitor. Highest incidence from March to June in North America. Frequency of epidemics depends on size of community, or proximity to a large center, amount of communication between large and small population groups, accretion of population by births and other less exactly determined factors. Much more likely to result in death from complicating pneumonia in children under 2 than at higher ages.

9. *Methods of control:*

A. The infected individual, contacts, and environment:

1. Recognition of the disease and reporting: Clinical symptoms. Special attention to rise of temperature, Koplik spots and catarrhal symptoms in exposed individuals.
2. Isolation: During period of communicability for the sake of the patient as well as others.
3. Concurrent disinfection: All articles soiled with the secretions of the nose and throat.
4. Terminal disinfection: Thorough cleaning.
5. Quarantine: When the disease is very prevalent and in large communities, quarantine of exposed susceptible children may be impracticable and of no value. Exclusion of exposed susceptible school children and teachers from school until 14 days from last exposure may be justifiable under other conditions. This applies to exposure in the household. Exclusion of exposed susceptible children from all public gatherings for the same period. If the date of only exposure is reasonably certain, an exposed susceptible child of school age may be allowed to attend school for the first 7 days of the incubation period. Quarantining of institutions of young children and of wards or dormitories where exposure is suspected is of some value. Strict quarantine of wards of infants if a case occurs in an institution is important.
6. Immunization: By the use of the serum or whole blood of convalescent patients, or of any healthy adults who have had measles, given within 5 days after exposure to a known case of measles, the attack in the exposed person may be averted in a high percentage of instances; if not averted, the disease is modified. Given later, but at a time prior to the clinical onset of the disease, convalescent serum usually modifies the severity of the attack and the patient probably acquires the usual lasting immunity to the disease.
7. Investigation of source of infection: Search for exposed susceptible children under 3 years of age is profitable. Carriers are not known to occur. Every effort should be made to have all cases reported early in the disease by the physician, or, if there is none in attendance, by parent or guardian. The chief object of discovering cases is to assure suitable care for little children and immunization if practicable of those exposed under 5 years of age.

B. General measures:

1. Daily examination of exposed children and of other possibly exposed persons. This examination should include record of the body temperature. A nonimmune exposed individual exhibiting a rise of temperature of 0.5° C. or more should be promptly isolated pending diagnosis.
2. Schools should not be closed or classes discontinued where daily observation of the children by physician and nurse is provided for.
3. Education as to special danger of exposing young children to those exhibiting fever and acute catarrhal symptoms of any kind, particularly during years and seasons of epidemic prevalence of measles.
4. In institutional outbreaks, immunization with convalescent serum of all minor inmates who have not had measles is of value in checking the spread of infection and in reducing mortality. No new admissions and no visitors under 16 years of age should be permitted in an institution for children, during a measles outbreak in the community or in the institution.
5. The immunization of infants and children under 3 years of age with convalescent serum or whole adult blood in families where cases of measles occur in older children or adults should be encouraged by the department of health and by private physicians.

Mumps.

1. *Recognition of the disease.*—Acute specific infection characterized by fever, swelling, and tenderness of the salivary glands, usually of the parotid, sometimes of the sublingual or submaxillary glands. Metastases occur sometimes in the ovaries and testicles. Epidemic occurrence is usual, especially in schools, colleges, and barracks, of new recruits. Inflammation of Stenson's duct may assist in early diagnosis. There are no laboratory aids of value.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—Secretions of the mouth and possibly of the nose.
4. *Mode of transmission.*—By direct contact with an infected person or with articles freshly soiled with the discharges from the nose and throat of such infected persons.
5. *Incubation period.*—From 12 to 26 days. The most common period 18 days, accepted as usual. A period of 21 days is not uncommon.
6. *Period of communicability.*—Unknown, but assumed to persist until the parotid gland has returned to its normal size.
7. *Susceptibility and immunity.*—Susceptibility believed to be general. Immunity follows an attack but second attacks of the disease are not rare. Brief passive immunity may follow inoculation with convalescent serum or whole blood.
8. *Prevalence.*—This disease is decidedly less prevalent than the other common communicable diseases of childhood such as measles, whooping cough, and chicken pox. Winter and spring are the seasons of greatest prevalence. Its occurrence is sporadic and epidemic except in large cities, where it is endemic.

9. *Methods of control:*

A. The infected individual, contacts, and environment:

1. Recognition of the disease and reporting: The diagnosis is usually made on swelling of the parotid gland.
2. Isolation: Separation of the patient from nonimmune children and young children and young people and exclusion of the patient from school and public places for the period of presumed infectivity, particularly when the disease appears in children's institutions or among young recruits.
3. Concurrent disinfection: All articles soiled with the discharges of nose and throat of the patient.
4. Terminal disinfection: None.
5. Quarantine: None. Exposed susceptible persons should be regularly inspected for the onset, the presence of initial symptoms of the disease, such as fever, or swelling or pain of the parotid, or submaxillary glands, for 3 weeks from the date of last exposure. Exposed children medically certified as having had the disease should not be excluded from school as susceptibles.
6. Immunization: None. Passive temporary immunity by convalescent serum or blood still in experimental stage.
7. Investigation of source of infection: Search for unreported or recent cases among associates of the patient in school or family or other group of young people. Carriers are not known to occur.

B. General measures: None.

Pneumonia, acute lobar.

1. *Recognition of the disease.*—An acute infection characterized by sudden onset with chill followed by fever, often pain in the chest, usually cough and dyspnœa. In many cases in children, vomiting and convulsions occur at the onset. Determination of the infecting microörganism by microscopic and cultural examination of the sputum is useful as an aid in therapy and for epidemiological studies. The X-ray may disclose pulmonary lesions before the stethoscope.
2. *Etiological agent.*—Various pathogenic bacteria commonly found in the nose, throat and mouth, such as the pneumococcus in about 95 per cent of the cases, and of these, 50 per cent types I and II; the bacillus of Friedländer; in occasional cases, the hæmolytic streptococcus; the influenza bacillus, etc.
3. *Source of infection.*—Probably discharges from the mouth and nose of infected person or carrier and articles freshly soiled with such discharges. Except when already attacked by some respiratory infection, exposed individuals rarely develop pneumonia as a result of transmission of infection by direct or indirect means from the patient.
4. *Mode of transmission.*—By direct contact with infected person or carrier, or with articles freshly soiled with the discharges of the nose and throat of such persons, and possibly from infected dust of rooms occupied by infected persons.
5. *Incubation period.*—Believed to be short, usually 1 to 3 days—not well determined.
6. *Period of communicability.*—Unknown; presumably until the discharges of the mouth and nose no longer carry the infectious agent in an abundant amount or in a virulent form.

7. *Susceptibility and immunity.*—Susceptibility is general, accentuated by wet and cold and exposure, and apparently under certain conditions by bodily and mental fatigue, and by alcoholism. Natural immunity may occur, but is doubtful. Acquired immunity to the particular microörganism may follow an attack of pneumonia; such immunity is of short duration. Artificial active or passive immunity cannot be relied upon.
8. *Prevalence.*—Common, and affecting at one time or other, between adolescence and old age, a large proportion of the population. No race or color or either sex is exempt from likelihood of having this disease. Occurs in all climates and seasons, but most often in winter and spring and in regions where cold, windy, changeable, and inclement weather prevails.
9. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms. Specific infecting organisms may be determined by serological and bacteriological tests early in the course of the disease, which may give basis for epidemiological studies and for specific serum therapy.
      2. Isolation: Medical aseptic technique preferably at home.
      3. Concurrent disinfection: Discharges from the nose and throat of the patient.
      4. Terminal disinfection: Thorough cleaning and airing.
      5. Quarantine: None
      6. Immunization: None.

   B. General measures:
      1. Whenever practicable and particularly in institutions, barracks, and on shipboard, crowding in living and sleeping places should be avoided. The general resistance should be conserved by good food, fresh air, sufficient sleep, temperance in the use of alcoholic beverages, and other hygienic measures.

Scarlet fever.

1. *Recognition of the disease.*—Sudden onset with nausea, vomiting, fever, and sore throat; rash (bright red spots on subcuticular flush) on second or third day. Cases occur without eruption, when provisional diagnosis may be made on sore throat, fever, vomiting, and history of exposure. The Schultz-Charlton blanching phenomenon may be used when rash has recently appeared: one-tenth to one-half cc convalescent serum or scarlet fever antitoxin is injected into skin where rash exists, which causes local blanching in 6 to 36 hours if rash is scarlatinal; absence of blanching, however, does not rule out scarlet fever.
2. *Etiological agent.*—A hæmolytic streptococcus.
3. *Source of infection.*—Discharges from the nose, throat, ears, abscesses, or wound surfaces of sick or convalescent patients, and articles freshly soiled therewith. The nose and throat discharges of carriers may also spread the disease.
4. *Mode of transmission.*—Directly by contact with an infected person, indirectly by articles freshly soiled with discharges of an infected person, or through contaminated milk or milk products, not by skin desquamation.
5. *Incubation period.*—Two to seven days, usually three to four days.
6. *Period of communicability.*—Usually until 3 weeks from the onset of the disease, without regard to the stage or extent of desquamation, but until all abnormal discharges have ceased and all open sores or wounds have healed.

Adults convalescent from scarlet fever appear to be less likely to transmit infection than are children. The infectious agent is more likely to be transmitted in colder seasons of the year.

7. *Susceptibility and immunity.*—Susceptibility is not general, particularly among adults. Unnoticed infections occur and produce immunity. Lasting immunity is usual after an attack, but not invariable, as second attacks occur. Artificial passive immunity of a few weeks may be developed by human convalescent serum. Artificial active immunity of uncertain duration can be developed in a considerable proportion of susceptible persons by the use of a suitable streptococcus antigen.
8. *Prevalence.*—Found in all parts of the world but unimportant in tropics and of low incidence in subtropical areas of North America. Commoner in urban than in rural areas. About 5 per cent of total deaths from scarlet fever occur in children under 1 year of age. Most common in winter and spring.
9. *Methods of control:*
   - A. The infected individual, contacts and environment:
     1. Recognition of the disease and reporting: By clinical symptoms.
     2. Isolation: In home or hospital, maintained in each case until the end of the period of communicability. If medical inspection is not available, isolation for 21 days from onset for uncomplicated cases.
     3. Concurrent disinfection: Of all articles which have been in contact with a patient and all articles soiled with discharges of the patient.
     4. Terminal disinfection: Thorough cleaning.
     5. Quarantine: Exclusion of exposed children and teachers from association with children, and food handlers from their work, until 7 days have elapsed since last exposure to a recognized case.
     6. Immunization: Exposed susceptibles, as determined by the Dick test, may be passively immunized by convalescent scarlet fever serum or scarlet fever antitoxin, under special circumstances.
     7. Investigation of source of infection: Search for individual source in contact cases or carrier, and in unpasteurized milk and milk products. It is important to discover undetected cases and convalescent and contact carriers.
   - B. General measures:
     1. Daily examination of exposed children and of other possibly exposed persons for a week after last exposure. Encourage removal of young susceptible contacts in the family to homes of adult friends for duration of communicable stage in the patient.

Septic sore throat.

1. *Recognition of the disease.*—Acute sore throat appearing in epidemic outbreaks, often of a highly virulent character, and accompanied by various general septicæmic manifestations. The onset is likely to be abrupt with chill, high temperature, and vomiting.
2. *Etiological agent.*—Streptococcus (hæmolytic type).[1]
3. *Source of infection.*—The human naso-pharynx, usually the tonsils, any case of acute streptococcus inflammation of these structures being a potential source of infection, including the period of convalescence of such cases.

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[1] Bovine mastitis of staphylococcus origin may lead to epidemic outbreaks of gastrointestinal disturbance in those who drink unpasteurized milk from a cow so infected.

The udder of a cow infected by the milker is a common source of infection. In such udders the physical signs of mastitis may be absent.[2]

4. *Mode of transmission.*—Direct or indirect human contact; consumption of raw milk contaminated by case or carrier or from an infected udder.
5. *Incubation period.*—One to three days.
6. *Period of communicability.*—In man, presumably during the continuance of clinical symptoms; in the cow, during the continuance of discharge of the streptococci in the milk, the condition in the udder tending to a spontaneous subsidence. The carrier stage may follow convalescence and persist for some time.
7. *Susceptibility and immunity.*—Susceptibility general, but somewhat less, in young children. Immunity, either natural or acquired, is rare and uncertain, if it occurs at all.
8. *Prevalence.*—Usually in epidemics, in any geographic area except where milk supply is pasteurized. Most cases in adolescents and adult milk drinkers. Most often in spring and early summer, but may occur at any season.
9. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms. Bacteriological examination of the lesions or discharges from the tonsils and naso-pharynx may be useful.
      2. Isolation: During the clinical course of the disease and convalescence, and particularly exclusion of the patient from participation in the production or handling of milk or milk products.
      3. Concurrent disinfection: Articles soiled with discharges from the nose and throat of the patient.
      4. Terminal disinfection: Cleaning.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of sources of infection: Search for cases and carriers among milkers and other handlers of unpasteurized milk, and for mastitis in milk cows.
   B. General measures:
      1. Exclusion of suspected milk supply from public sale or use until pasteurized. The exclusion of the milk of an infected cow or cows in small herds is possible when based on bacteriological examination of the milk of each cow, and preferably the milk from each quarter of the udder at frequent intervals. Exclusion of human cases or carriers from handling milk or milk products.
      2. Pasteurization of all milk.
      3. Education in the principles of personal hygiene and avoidance of the use of common towel, drinking and eating utensils.
      4. In the absence of an epidemic, the milk of any cow with evidence of mastitis should be excluded from sale or use as a protection in addition to pasteurization.

Tuberculosis, pulmonary.

1. *Recognition of the disease.*—Evidence of present or past infections in the absence of clinical symptoms can be determined by a variety of specific tuberculin reactions, among which the Mantoux intradermal test is the

[2] Mastitis in the cow, due to bovine streptococci, is not a cause of septic sore throat in human beings unless a secondary infection of the udder by a human type of streptococcus takes place.

most reliable. In the presence of early constitutional symptoms with or without pulmonary signs, the existence or location of pulmonary or other thoracic lesions can best be revealed by the X-ray. When fever, cough, loss of appetite and weight, and physical signs on auscultation and percussion are found, the pulmonary lesion is already well developed. Discovery of tubercle bacilli in the sputum confirms the diagnosis not infrequently in early cases but is an evidence usually of a well-advanced lesion.

2. *Etiological agent.*—**Mycobacterium tuberculosis (hominis)** (*Bacillus tuberculosis* (*human*)). Tubercle bacilli of bovine type have been isolated from pulmonary lesions in man; avian type rarely.
3. *Source of infection.*—The specific microörganism present in the discharges, or articles freshly soiled from the discharges, from any open tuberculosis lesions, the most important discharge being sputum. Of less importance are discharges from the intestinal and genitourinary tracts, or from lesions of the lymph nodes, bone, and skin.
4. *Mode of transmission.*—Usually through the discharges of the respiratory tract, occasionally through those of the digestive tract, by direct or indirect contact with infected persons, by means of coughing, sneezing, or other droplet infection, by kissing, by the use of contaminated eating and drinking utensils, and possibly by contaminated flies and dust. Infection rarely occurs from casual contact, but usually results from the continued type of exposure characteristic of family relationships.
5. *Incubation period.*—Variable and dependent upon the type of the disease.
6. *Period of communicability.*—As long as the specific microörganism is eliminated by the host. Commences when a lesion becomes an open one, i. e., discharging tubercle bacilli, and continues until it heals or death occurs. The degree of communicability varies with the number and virulence of the bacilli discharged, the frequency of exposure, and the susceptibility of the persons exposed.
7. *Susceptibility and immunity.*—Susceptibility is general; in children greater than in adults; in aboriginal races more than among races long exposed to the disease; in the undernourished, fatigued, and neglected more than in the well fed and well cared for; in those exposed to dusty trades, and in particular to silica dust, more than in persons with outdoor occupations in clean air. Resistance of some degree is developed by age and by the maintenance of good nutrition.
8. *Prevalence.*—Among the most common communicable diseases of man, with but slight variations of occurrence of infection, although considerable variation in mortality rate according to race. At present in some modern occidental nations its incidence as a disease has fallen markedly, and both incidence and deaths continue to fall from year to year. Infection occurs more commonly in childhood (from infancy to adolescence) than at later ages. Mortality highest among males between 25 and 40 and among females about 5 years earlier. Aboriginal races when first exposed develop the disease in a rapidly fatal form.
9. *Methods of control:*

   A. The infected individual, contacts, and environment:

      1. Recognition of the disease and reporting: By thorough physical examination supplemented by use of the X-ray and tuberculin testing when necessary and confirmed by bacteriological examination of sputum and other materials. Early discovery in contacts, particularly in family groups exposed to an open case of tuberculosis ("positive" sputum), is of great importance.

2. Isolation of such "open" cases as do not observe the precautions necessary to prevent the spread of the disease may prove advisable. A period of hospital or sanatorium treatment is very desirable in all cases to remove the patient as a focus of infection in his home, and to teach him the hygienic essentials of tuberculosis control as well as to increase his chances of recovery.
3. Concurrent disinfection: Of sputum and articles soiled with it. Particular attention should be paid to prompt disposal or disinfection of sputum itself, of handkerchiefs, cloths, or paper soiled therewith, and of eating utensils used by the patient.
4. Terminal disinfection: Cleaning and renovation.
5. Quarantine: None.
6. Immunization: None.
7. Investigation of source of infection: In spite of the length and uncertainty of the incubation period and the numerous possible sources of infection, a systematic effort should be made to discover the probable source in each case and to identify other cases of the same origin, by thorough examination by X-ray, physical examination, and where appropriate by tuberculin test of family and household contacts.

B. General measures:

1. Education of the public in regard to the danger of tuberculosis, the mode of spread and the methods of control, with especial stress upon the danger of exposure and infection in early childhood.
2. Provision of dispensaries and visiting-nurse service for discovery of early cases and supervision of home cases.
3. Provision of adequate sanatorium facilities for isolation and treatment of active cases. Two beds per annual tuberculosis death in the community is an adequate ratio.
4. Provision of open-air schools and preventoria for infected children not yet showing clinical signs of the disease.
5. Improvement of housing conditions and nutrition of the poor.
6. Elimination of silica dust in certain industrial establishments.
7. Improvement of habits of personal hygiene and betterment of living conditions among the underprivileged.
8. Separation of babies from tuberculous mothers at birth.
9. Pasteurization of all milk supplies.
10. Eradication of tuberculosis in cattle.
11. Where the disease is endemic and the incidence high particularly among little children, the routine use of B. C. G. (bile Calmette Guérin) vaccine in infancy for active immunization has been suggested.

Tuberculosis, other than pulmonary.

1. *Recognition of the disease.*—By local manifestations, by constitutional reactions, by specific reactions, and by microscopic identification of the tubercle bacillus in the lesions or their discharges.
2. *Etiological agent.*—**Mycobacterium tuberculosis (hominis et bovis)** (*Bacillus tuberculosis* (*human and bovine*)).
3. *Source of infection.*—Discharges from mouth, nose, bowel, and genito-urinary tract of infected human beings; the discharging lesion of bones, joints, and lymph glands; articles freshly soiled with such discharges; milk from tuberculous cattle.

4. *Mode of transmission.*—By direct contact with infected persons, by contaminated food, and possibly by contact with articles freshly soiled with the discharges of infected persons.
5. *Incubation period.*—Unknown.
6. *Period of communicability.*—Until discharging lesions are healed.
7. *Susceptibility and immunity.*—(See statement under this heading in Pulmonary tuberculosis.)
8. *Prevalence.*—Much less common than the pulmonary form and more rapidly falling in incidence, representing about 10 per cent of total cases and deaths from the disease. Especially common in infants and young children where intimately exposed to parent infection and to bovine infection through unpasteurized milk from tuberculous cattle.
9. *Methods of control:*
   A. The infected individual, contacts and environment:
      1. Recognition of the disease and reporting: Clinical signs and symptoms confirmed by bacteriological and serological examinations.
      2. Isolation: None.
      3. Concurrent disinfection: Discharges and articles freshly soiled with them.
      4. Terminal disinfection: Cleaning.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Search should be made for possible original source in family, household, or other intimate contacts, and to discover previously unrecognized cases of similar origin, such a search to be aimed at discovery of infected but latent or arrested cases as well as those showing an active process. Special inquiry and investigation should be made to discover possible source of bovine tubercle infection where unpasteurized milk has been used in the family or particularly used uncooked, by the patient.
   B. General measures:
      1. Pasteurization of milk and milk products and inspection of meats.
      2. Eradication of tuberculosis in dairy cattle.
      3. Patients with open lesions should be prohibited from handling foods.
      4. Adequate hospital, sanatorium, preventorium, and out-patient facilities for discovery, control, and clinical management.

Whooping cough (Pertussis).

1. *Recognition of the disease.*—An acute infection involving trachea and bronchi and characterized by an initial catarrhal stage with slight fever, and a paroxysmal stage in which the paroxysmal cough ends in a sonorous or whooping inspiration often accompanied by vomiting. Identification of the Bordet-Gengou bacillus in the tenacious tracheo-bronchial mucus can be made in a high percentage of cases during the early and paroxysmal stages of the disease before the whoop develops, and less readily from the fourth to the sixth week after the onset of the disease by the use of special cough culture plates held before the mouth during a spontaneous or induced paroxysm of coughing. A definite lymphocytosis in the pre-paroxysmal stage may assist the clinical diagnosis.
2. *Etiological agent.*—**Hæmophilus pertussis** (*Bacillus of Bordet-Gengou*).
3. *Source of infection.*—Discharges from the laryngeal and bronchial mucous membranes of infected persons.

4. *Mode of transmission.*—Contact with an infected person, or with articles freshly soiled with the discharges of such person.
5. *Incubation period.*—Commonly 7 days, almost uniformly within 10 days, and not exceeding 16 days.
6. *Period of communicability.*—Particularly communicable in the early catarrhal stage before the characteristic whoop makes a clinical diagnosis possible. The catarrhal stage occupies from 7 to 14 days. After the characteristic whoop has appeared, the communicable period continues certainly for 3 weeks. Even if the spasmodic cough with whoop persists longer than this it is most unlikely that the infecting organism can be isolated from the discharges. The communicable stage must be considered to extend from 7 days after exposure to an infected individual to 3 weeks after the development of the characteristic whoop.
7. *Susceptibility and immunity.*—Susceptibility is general. There is no natural immunity. The greatest susceptibility is in children between 6 months and 5 years of age, after which there is some decrease. One attack confers a definite and prolonged immunity, although second attacks do occur. A brief passive immunity may be conveyed to young children by convalescent serum or adult whole blood. Artificial immunity is still of doubtful value and as yet of no definite reliance. Susceptibility is apparently higher in females at all ages than in males.
8. *Prevalence.*—Very prevalent, and a common disease among children everywhere regardless of race, climate, or geographical location. About half the reported cases in cities are in children under 5 years of age, and 90 per cent in children under 10. Incidence and fatality rates are higher among females. Somewhat less prevalent in tropical than in temperate climates. Seasonal incidence variable, but mortality higher usually in spring months in North America. Cyclical occurrence irregular.
9. *Methods of control.*

   A. The infected individual, contacts and environment:

   1. Recognition of the disease and reporting: Clinical symptoms, supported by a differential leucocyte count, and confirmed where possible by bacteriological examination of bronchial secretions. A positive diagnosis may be made by bacteriological examination of laryngeal discharges as early as 1 week before the development of the characteristic cough.
   2. Isolation: Separation of the patient from susceptible children, and exclusion of the patient from school and public places for the period of assumed infectivity. It is of particular importance to protect children under 3 years of age against contact with any other children with cough and fever, of whatever origin, and especially if whooping cough is suspected or is known to be prevalent. Isolation of children over 2 years of age is impracticable, and even those under 2 should not be insisted upon at the expense of fresh air in the open if weather permits.
   3. Concurrent disinfection: Discharges from the nose and throat of the patient and articles soiled with such discharges.
   4. Terminal disinfection: Cleaning of the premises used by the patient.
   5. Quarantine: Limited to the exclusion of nonimmune children from school and public gatherings for 10 days after their last exposure to a recognized case. This precaution may be omitted

if exposed nonimmune children are observed with care by a physician or nurse on their arrival at school each day for 10 days after their last exposure to a recognized case.

6. Immunization: Use of prophylactic vaccination is recommended by some observers, but is still considered to be of doubtful reliability.
7. Investigation of source of infection: An effort should be made to discover undiagnosed and unreported cases, with the main object in view of protecting young children from exposure, and thus reducing the mortality. Postponement of the age of infection at least until school age and great care in the management of the disease in young children offer some hope of reducing deaths from whooping cough although reduction of incidence by any means appears unlikely. Carriers in the exact sense of this term are not known to occur.

B. General measures: Education in habits of personal cleanliness and in the dangers of association or contact with those showing catarrhal symptoms with cough.

GROUP II. DISEASES TRANSMITTED BY DISCHARGES FROM THE INTESTINAL TRACT

Cholera.
Dysentery, amœbic.
Dysentery, bacillary.
Hookworm disease.
Paratyphoid fever.
Typhoid fever.

Cholera.

1. *Recognition of the disease.*—In a few mild cases, diarrhœa may be the chief or only symptom. In the typical case, rice-water stools, vomiting, and general symptoms of dehydration occur with thirst, pain, and coma. The cholera vibrios are found in the stools.
2. *Etiological agent.*—**Vibrio comma.** (*Spirillum choleræ.*)
3. *Source of infection.*—Bowel discharges and vomitus of infected persons, and fæces of convalescent or healthy carriers. Ten per cent of contacts may be found to be carriers.
4. *Mode of transmission.*—By food and water polluted by infectious agent; by contact with infected persons, carriers, or articles freshly soiled by their discharges; by flies.
5. *Incubation period.*—One to five, usually three days, occasionally longer if the healthy carrier stage, before development of symptoms, is included.
6. *Period of communicability.*—Usually 7 to 14 days or longer and until the infectious organism is absent from the bowel discharges. A high degree of communicability is usual.
7. *Susceptibility and immunity.*—Susceptibility is general, although natural immunity appears to exist to a limited degree. Acquired immunity is uncertain. Active artificial immunity for about 1 year may be obtained by vaccines.
8. *Prevalence.*—Rare in North America. Appears in epidemic form frequently in the Philippines. Does not occur sporadically, except as an isolated case is discovered in the course of maritime quarantine enforcement.
9. *Methods of control:*

A. The infected individual, contacts, and environment:

1. Recognition of the disease and reporting: Clinical symptoms confirmed by bacteriological examination of stools.

2. Isolation of patient in hospital or screened room during communicable period.
3. Concurrent disinfection: Prompt and thorough disinfection of the stools and vomited matter. Articles used by and in connection with the patient must be disinfected. Food left by the patient should be burned.
4. Terminal disinfection: The room in which a sick patient was isolated should be thoroughly cleaned.
5. Quarantine: Contacts for 5 days from last exposure, or longer if stools are found to contain the cholera vibrio.
6. Immunization: Prophylactic immunization of contacts is useful and advisable.
7. Investigation of source of infection: Search for contaminated food and water as common origin of groups of cases, and for unreported cases and for carriers.

B. General measures:

1. Rigid personal prophylaxis of attendants by scrupulous cleanliness, disinfection of hands each time after handling patient or touching articles contaminated by dejecta, the avoidance of eating or drinking anything in the room of the patient, and the prohibition of those attendant on the sick from entering the kitchen.
2. The bacteriological examination of the stools of all contacts to determine carriers. Isolation of carriers.
3. Water should be boiled, if used for drinking or toilet purposes, or if used in washing dishes or food containers, unless the water supply is adequately protected against contamination or is so treated, as by chlorination, that the cholera vibrio cannot survive in it.
4. Careful supervision of food and drink: Where cholera is prevalent, only cooked foods should be used. Food and drink after cooking or boiling should be protected against contamination, as by flies and human handling.

C. Epidemic measures: Inspection service for early detection and isolation of cases; examination of persons exposed in infected centers for detection of carriers, with isolation or control of carriers; cleaning of rooms occupied by the sick, and the detention, in suitable camps for 5 days, of those desirous of leaving for another locality. Those so detained should be examined for detection of carriers.

Dysentery, amœbic (Amœbiasis).

1. *Recognition of the disease.*—Insidious and undetermined onset characterizes mild acute cases, with digestive disturbance, anorexia, diarrhœa or constipation, and usually little abdominal discomfort. Severe acute cases following massive infection may simulate acute appendicitis, or other acute surgical abdominal condition with high temperature and severe prostration. The subacute and chronic forms of the disease vary widely in the extent of local and constitutional symptoms. There may or may not be diarrhœa or constipation; or these may alternate in the same patient.
2. *Etiological agent.*—**Endamœba histolytica.**
3. *Source of infection.*—The bowel discharges of infected persons and of carriers.
4. *Mode of transmission.*—By drinking contaminated water and by eating infected foods, especially those that are commonly served cold and moist, and

hand-to-mouth transfer of infected material; from moist objects soiled with discharges of an infected individual; by flies.

5. *Incubation period.*—From 2 days in severe infections to several months in subacute and chronic cases; commonly 3 to 4 weeks.
6. *Period of communicability.*—During course of infection and until repeated microscopic examination of stools shows absence of the *Endamœba histolytica* (either trophozoites or cysts). Direct transmission unusual.
7. *Susceptibility and immunity.*—Susceptibility to infestation is general; immunity uncertain; no artificial immunity.
8. *Prevalence.*—Not a common disease clinically in continental North America. Epidemic outbreaks are rare. It is estimated that almost 5 per cent of the population are carriers of cysts.
9. *Methods of control:*

   A. The infected individual, contacts and environment:

      1. Recognition of the disease and reporting: Clinical symptoms confirmed by microscopic examination of stools.
      2. Isolation: None.
      3. Concurrent disinfection: Sanitary disposal of the bowel discharges. Hand washing after use of toilet.
      4. Terminal disinfection: Cleaning.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Microscopic examination of stools of inmates of the household, or of work associates of the infected person, and of other suspected contacts, should be supplemented by search for direct contamination of water and foods by human fæces.

   B. General measures:

      1. Sanitary disposal of human fæces.
      2. Protection of potable water supplies against fæcal contamination, and boiling drinking water where necessary. Chlorination of water supplies as generally used has been found inadequate for the destruction of cysts.
      3. Supervision of the general cleanliness, of the personal health and sanitary practices of persons preparing and serving food in public eating places, especially moist foods eaten raw.
      4. Education in personal cleanliness, particularly washing hands with soap and water after evacuation of the bowel.
      5. Control of fly breeding and protection of foods against fly contamination by screening.
      6. It is of importance that all cross connections between potable and polluted water supplies be forbidden. Systematic inspection should be made to discover them, and the supply should be disconnected until such cross connections have been eliminated.
      7. Instruction of convalescent and chronic carriers in personal hygiene, particularly as to sanitary disposal of fæcal waste, and hand washing after use of toilet.

   C. Epidemic measures: In case of epidemics due to relatively massive doses of infectious material, active measures should be employed to discover the source of infection, and to warn the public and the medical profession of the early and characteristic symptoms, and of the serious immediate and remote results of such infection.

Dysentery, bacillary.

1. *Recognition of the disease.*—The typical case exhibits an acute onset, fever, tenesmus, with frequent stools containing blood and mucus. One or more of a large number of possible types of the dysentery bacillus can usually be found in the stools in the first 2 days of the disease.
2. *Etiological agent.*—**Shigella dysenteriæ** and **Shigella paradysenteriæ.**
3. *Source of infection.*—The bowel discharges of infected persons.
4. *Mode of transmission.*—By eating infected foods, and by hand-to-mouth transfer of infected material; by flies, from objects soiled with discharges of an infected individual or of a carrier; by drinking contaminated water. Polluted milk and water are less common vehicles of this disease than is the case with typhoid fever.
5. *Incubation period.*—2 to 7 days.
6. *Period of communicability.*—During the febrile period of the disease and until the microörganism is absent from the bowel discharges, sometimes as long as 4 weeks.
7. *Susceptibility and immunity.*—Susceptibility is general among children, but less so, and the disease less severe, in adults. A relative and not permanent immunity follows recovery from the disease.
8. *Prevalence.*—Endemic, epidemic, and sporadic, but shares with other enteric infections in striking and progressive reduction wherever water supplies are rendered safe, sewage is disposed of in a sanitary manner, milk is pasteurized, and infant hygiene is of a good order. Most common in the summer months and in subtropical and tropical areas.
9. *Methods of control*:
   - A. The infected individual, contacts, and environment:
     1. Recognition of the disease and reporting: Clinical symptoms confirmed by serological and bacteriological tests; groups of cases of acute diarrhœal disorder should always be reported at once.
     2. Isolation: Infected individuals during the communicable period of the disease, particularly rigid personal precautions by attendants.
     3. Concurrent disinfection: Bowel discharges.
     4. Terminal disinfection: Cleaning.
     5. Quarantine: None.
     6. Immunization: Vaccines may give some immunity. Owing to severe reactions their use is not recommended, nor should vaccination be made compulsory except under extreme emergency.
     7. Investigation of source of infection: Search for a common source in contaminated food and water, and for carriers particularly among food handlers, should be undertaken as in the case of typhoid fever.
   - B. General measures:
     1. Protection and purification of public water supplies, together with prevention of subsequent contamination.
     2. Pasteurization of public milk supplies; use of boiled milk for infant feeding.
     3. Supervision of preparation and handling of other foods, particularly those which are moist and eaten raw.
     4. Hand washing, by food handlers in particular, following use of toilet.
     5. Prevention of fly-breeding; screening.
     6. Sanitary disposal of human excreta.

7. Persons known to be infected, and their attendants, should be excluded from handling food for public consumption, and from handling the family food supply if possible.
8. The exercise of rigid precautions in known cases of bacillary dysentery is requisite but is inadequate as a safeguard against the ever-present risk of infection from concealed sources. Reduction of high infant mortality rates is dependent upon prevention of diarrhœa and enteritis. Infant hygiene, including breast feeding, scrupulous cleanliness at all times in the preparation and handling of food for children, and continuous attention to diet in order to avoid minor digestive disturbances that may lower resistance to the infection will do much toward accomplishing this aim. As a precautionary measure, all cases of infantile diarrhœa should be regarded as bacillary dysentery. Prevention of epidemics of bacillary dysentery by guarding against massive dissemination of infection should be a major concern, particularly in prisons, camps, and institutions.

Ancylostomiasis (Hookworm disease).

1. *Recognition of the disease.*—Light degrees of infestation may produce no striking clinical symptoms, although some degree of secondary anæmia and slight interference with bodily and mental development may be noted. A medium degree of infestation shows marked anæmia and, if before puberty, definite physical and mental retardation, and a dry dirty-yellow skin. Severe infestations may show petechiæ and atrophy of the skin, œdema, general or of dependent parts, extreme anæmia, anxious, stupid expression, prominent abdomen. The diagnosis is definitely established by finding ancylostoma ova in the stools, by smear or flotation methods.
2. *Etiological agent.*—In the United States, **Necator americanus**, rarely **Ancylostoma duodenale.**
3. *Source of infestation.*—Fæces of infested persons. Infestation generally takes place through the skin, occasionally by the mouth.
4. *Mode of transmission.*—The larval forms pierce the skin, usually of the foot, and, passing through the lymphatics to the vena cava and the right heart, thence in the blood stream to the lungs, they pierce the capillary walls and pass into the alveoli. They then pass up the bronchi and trachea to the throat, whence they are swallowed and finally lodge in the small intestine. Also by drinking water containing larvæ, by eating soiled food, by hand-to-mouth transmission of the eggs or larvæ from objects soiled with infested discharges. The chief reservoir of infectious material is *contaminated soil.*
5. *Incubation period.*—No incubation period occurs comparable to that observed in bacterial and virus infections. Onset of symptoms varies widely in time, according to the intensity of the infestation, from 2 to 3 weeks in massive infestations (commonly 7 to 10 weeks), to many months or even years where infestation or reinfestation is by small numbers of worms. The free living form may exist in the soil under favorable conditions for several weeks. Eggs are found in the stools in about 4 to 6 weeks after the larvæ penetrate the skin, and develop the next generation of larvæ 5 to 8 days after being deposited on soil, under favorable conditions.
6. *Period of communicability.*—As long as the parasite or its ova are found in the bowel discharges of an infested individual. Contaminated soil may remain infective for 5 months in the absence of freezing. An individual can communicate the disease to others only by the indirect method of pollution of the soil with his fæces. As long as mature female worms are

in the intestine, eggs, if deposited in the fæces in warm moist soil, become sources of infestation, especially where the soil is sandy.

7. *Susceptibility and immunity.*—Susceptibility to infestation is universal, although among adults, especially Negroes, infestations are likely to be less heavy than among children and in the white races. Immunity does not develop after infestation.
8. *Prevalence.*—Endemic widely throughout those climatic belts where frost does not last more than 6 weeks in the year, and particularly where the soil is sandy. In rural areas of the Southern States of the United States, particularly among white children of school age; less commonly and less severely among Negro children. Damp summer weather increases the prevalence of infestation. During the past two decades there has been some decrease in prevalence and severity of the disease in continental United States. Prevalence is high in Puerto Rico.
9. *Methods of control:*
   - A. The infested individual, contacts, and environment:
     1. Recognition of the disease and reporting: Microscopic examination of bowel discharges.
     2. Isolation: None.
     3. Concurrent disinfestation: Sanitary disposal of bowel discharges to prevent contamination of soil and water.
     4. Terminal disinfestation: None.
     5. Quarantine: None.
     6. Immunization: None.
     7. Investigation of source of infestation: Each case and carrier is a potential or actual spreader of the disease and should be brought under treatment and his family contacts examined.
     8. Treatment: Appropriate treatment of infested persons with carbon tetrachloride, oil of chenopodium, or tetra-chlor-ethylene, to rid the intestinal canal of the parasite and its ova.
   - B. General measures:
     1. Education as to dangers of soil pollution and methods of prevention.
     2. Prevention of soil pollution by installation of sanitary disposal system for human discharges, especially sanitary privies in rural areas.
     3. Personal prophylaxis by cleanliness and the wearing of shoes.

Paratyphoid fever.

1. *Recognition of the disease.*—A general infection with the paratyphoid bacillus characterized especially by continued fever and involvement of the lymphoid tissues in the intestine, enlargement of the spleen, and a variety of constitutional symptoms, sometimes rose spots on the trunk, usually diarrhœal disturbance. The infecting microörganism may be found in the fæces, blood, and urine. This disease should not be confused with food poisoning or with infection due to enteritidis bacilli of animal origin.
2. *Etiological agent.*—**Salmonella paratyphi** (*Paratyphoid bacillus A*); **Salmonella shottmülleri** (*Paratyphoid bacillus B*).
3. *Source of infection.*—Bowel discharges and urine of infected persons, and water or foods contaminated with such discharges of infected persons or of healthy carriers. Healthy carriers may be numerous in an outbreak.
4. *Mode of transmission.*—Directly by personal contact: indirectly by contact with articles freshly soiled with the discharges of infected persons or through milk, water, or food contaminated by such discharges, probably by flies.

5. *Incubation period.*—Four to ten days; average, seven days.
6. *Period of communicability.*—From the appearance of prodromal symptoms, throughout the illness and relapses, during convalescence, and until repeated bacteriological examination of discharges shows absence of the infecting organism.
7. *Susceptibility and immunity.*—Susceptibility is general. Natural immunity probably exists in some adults. Acquired immunity is usually permanent after recovery from the disease. Artificial active immunity of probably 2 years' duration can be developed by the use of vaccines.
8. *Prevalence.*—Frequency has fallen with that of typhoid fever until in most parts of North America it is relatively rare, occurring sporadically or in small local carrier or contact epidemics. Probably nowhere endemic in North America.
9. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms confirmed by specific agglutination test, or by bacteriological examination of blood, bowel discharges, or urine.
      2. Isolation: In fly-proof room, preferably under hospital conditions, of such cases as cannot command adequate sanitary environment and nursing care in their homes.
      3. Concurrent disinfection: Disinfection of all bowel and urinary discharges and articles soiled with them.
      4. Terminal disinfection: Cleaning.
      5. Quarantine: None.
      6. Immunization: Of exposed susceptibles.
      7. Investigation of source of infection: Search for common source in polluted water, milk, shellfish or other food, and individual sources as unreported cases and carriers.
   B. General measures:
      1. Protection and purification of public water supplies.
      2. Pasteurization of public milk supplies.
      3. Limitation of collection and marketing of shellfish to those from approved sources.
      4. Supervision of other food supplies, and of food handlers.
      5. Prevention of fly breeding.
      6. Sanitary disposal of human excreta.
      7. Extension of immunization by vaccination to persons especially subject to exposure by reason of occupation and travel, to those living in areas of high endemic incidence of typhoid fever and to those for whom the procedure can be systematically and economically applied, as military forces and institutional populations, depending on prevalence of the disease.
      8. Discovery and supervision of partyphoid carriers and their exclusion from the handling of foods.
      9. Exclusion of suspected milk supplies on epidemiological evidence pending discovery and elimination of the personal or other cause of contamination of the milk.
      10. Exclusion of suspected water supplies until adequate protection or purification is provided unless all water used for toilet, cooking, and drinking purposes is boiled before use.

Typhoid fever.

1. *Recognition of the disease.*—A general infection with the typhoid bacillus, characterized by a continued fever, and by involvement of the lymphoid tissues especially with enlargement and often ulceration of Peyer's patches, enlargement of the spleen, usually rose spots on the trunk, diarrhœal disturbance, and a variety of severe constitutional disturbances accompanying parenchymatous involvement of various viscera. The infecting microörganism can be found in the blood, the fæces, and the urine.
2. *Etiological agent.*—**Eberthella typhosa** (*Bacillus typhosus*).
3. *Source of infection.*—Bowel discharges and urine of infected individuals. Healthy carriers are common.
4. *Mode of transmission.*—Conveyance of the specific microörganism by direct or indirect contact with a source of infection. Among indirect means of transmission are contaminated water, milk, and shellfish, and probably flies.
5. *Incubation period.*—From 3 to 38 days, usually 7 to 14 days.
6. *Period of communicability.*—From the appearance of prodromal symptoms, throughout the illness and relapses during convalescence, and until repeated bacteriological examinations of the discharges show continuous absence of the infecting organism.
7. *Susceptibility and immunity.*—Susceptibility is general. Natural immunity exists to some extent in adults. Acquired immunity of permanent duration usually follows recovery from the disease. Artificial active immunity of probably 2 years' duration can be developed by the use of typhoid vaccine.
8. *Prevalence.*—Widespread throughout the world regardless of race, age, sex, climate, or geography. Formerly in most large cities of North America and in many extensive rural areas in endemic and epidemic form, and still endemic in some rural areas of the southern United States but commonly now occurring in sporadic cases and as small contact and carrier epidemics. Steadily falling in incidence, particularly in all urban areas supplied with water of a sanitary quality and pasteurized milk, and where human fæcal waste is disposed of without polluting water supplies, food, or surface of the soil.
9. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms confirmed by specific agglutination test and bacteriological examination of blood, bowel discharges, or urine.
      2. Isolation: In fly-proof room, preferably under hospital conditions, of such cases as cannot command adequate sanitary environment and nursing care in their homes. Release from isolation should be determined by two successive negative cultures of stool and urine specimens collected not less than 24 hours apart.
      3. Concurrent disinfection: Disinfection of all bowel and urinary discharges and articles soiled with them.
      4. Terminal disinfection: Cleaning.
      5. Quarantine: None.
      6. Immunization: Of susceptibles in the family or household of the patient who have been exposed or may be exposed during the course of the disease.
      7. Investigation of source of infection: The actual or probable source of infection of every case should be determined by searching for common and individual sources: 1. Polluted water, milk, shellfish, and other food supplies; 2. Unreported cases and carriers.

B. General measures:

1. Protection and purification of public water supplies.
2. Pasteurization of public milk supplies.
3. Limitation of collection and marketing of shellfish to those from approved sources.
4. Sanitary disposal of human excreta.
5. Supervision of other food supplies, and of food handlers.
6. Prevention of fly breeding.
7. Extension of immunization by vaccination to persons subject to unusual exposure by reason of occupation or travel, to those living in areas of high endemic incidence of typhoid fever and to those for whom the procedure can be systematically and economically applied, as in the military forces and institutional populations.
8. Discovery and supervision of such typhoid carriers, and their exclusion from the handling of foods, as epidemiological and bacteriological evidence indicate are of importance.
9. Exclusion of suspected milk supplies on epidemiological evidence pending discovery and elimination of the cause of contamination of the milk.
10. Exclusion of suspected water supply, until adequate protection or purification is provided unless all water used for toilet, cooking, and drinking purposes is boiled before use.
11. Education of the general public and particularly of food handlers, concerning the sources of infection, and modes of transmission of the disease.
12. Instruction of convalescents and chronic carriers in personal hygiene, particularly as to sanitary disposal of fæcal waste, and handwashing after use of toilet, and restraint from acting as food handlers.

GROUP III. DISEASES TRANSMITTED BY INSECTS AND OTHER ARTHROPODS

Dengue.
Malaria.
Plague.
Typhus fever.
Yellow fever.
Others, not here discussed:
- Filariasis.

Others, not here discussed—Continued.
- Leishmaniasis.
- Relapsing fever.
- Rocky Mountain fever.
- Trench fever.
- Tsutugamuchi fever.
- Tularæmia.

Dengue.

1. *Recognition of the disease.*—An acute febrile infection of sharp onset with two paroxysms, of short duration. Intense headache, joint and muscle pains, and irregular eruption are usual.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—The blood of infected persons, during first 3 days of the disease.
4. *Mode of transmission.*—By the bite of infected mosquitoes, *Aëdes œgypti,* from 11 days after biting a patient during the first 5 days of the disease, until the death of the mosquito.
5. *Incubation period.*—Three to 10 days.
6. *Period of communicability.*—From the day before onset to the fifth day of the disease. Degree of communicability depends on prevalence of infected humans and abundance of *Aëdes œgypti* mosquitoes.

7. *Susceptibility and immunity.*—Susceptibility apparently universal. Acquired immunity may last a few months to a year. After several attacks an almost complete immunity is developed.
8. *Prevalence.*—Occurs only where the *Aëdes ægypti* mosquito exists, mainly in tropics and subtropics. When occurring in epidemic form in the United States, begins usually in southernmost States, moving north until the range of the vector mosquito is stopped by climate or the season of the year. Common, and in frequent epidemics, in the Philippines. Occurs equally among males and females; less among indigenous than among visiting or transient whites where the disease commonly occurs.
9. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting.
      2. Isolation: The patient must be kept in a screened room.
      3. Concurrent disinfection: None.
      4. Terminal disinfection: None.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Search for unreported or undiagnosed cases and for the *Aëdes ægypti* mosquito and its breeding places.
   B. General measures: Measures directed toward elimination of mosquitoes (*Aëdes ægypti*). Screening of rooms.

Malaria.

1. *Recognition of the disease.*—A group of specific infectious fevers due to invasion of the red blood cells by 1 of at least 3 types of Sporozoa of the genus *Plasmodium.* These fevers occur endemically or epidemically and are associated with a symptom complex fairly characteristic of each variety, marked particularly by periodicity of fever and symptoms due to the growth and development of the organism. Enlargement of the spleen, secondary anæmia, and the characteristic recurrence of chills and fever as clinical findings are confirmed by observing presence of the malaria parasites in blood film on microscopic examination. Mosquitoes of anopheline family are the only known vectors.
2. *Etiological agent.*—The several species of microörganisms: **Plasmodium vivax,** causing *benign tertian malaria,* **Plasmodium falciparum,** causing *malignant tertian (æstivo-autumnal) malaria,* and **Plasmodium malariæ** (causing *quartan malaria*).
3. *Source of infection.*—The blood of an infected individual.
4. *Mode of transmission.*—By the bite of infected *Anopheles* mosquitoes. The mosquito is infected by biting an individual suffering from acute or chronic malaria. The parasite develops in the body of the mosquito for from 10 to 14 days (21 days for quartan), after which time the sporozoites appear in its salivary glands.
5. *Incubation period.*—Varies with the type of species of infecting microörganism and the amount of infection, usually 14 days in the tertian variety.
6. *Period of communicability.*—As long as the sexual form of the malaria microörganism exists in the circulating blood in sufficient quantities to infect mosquitoes. In untreated cases this may last for months.
7. *Susceptibility and immunity.*—Susceptibility is universal. Negroes appear to suffer less severely from the disease. Some relative immunity appears to follow repeated attacks of the disease. A state of good nutrition is be-

lieved to be a factor in maintaining resistance to the disease and in spontaneous recovery.

8. *Prevalence.*—Endemic and sporadic, occurring more frequently among children than adults, and more among Negroes than among whites. Particularly prevalent in the southeast coastal plain, Mississippi Valley, south of St. Louis, in eastern Texas, New Mexico, Louisiana, Arkansas, southern Missouri, and slightly in California and Oregon. Serious in Puerto Rico and the Philippines. Seasonal occurrence of tertian type in early summer, æstivo-autumnal in early fall.

9. *Methods of control:*

A. The infected individual, contacts and environment:

1. Recognition of the disease and reporting: Clinical symptoms, always to be confirmed by microscopical examination of the blood. Repeated examination of blood films may be necessary.
2. Isolation: The individual with malarial parasites in his blood should be protected from the bites of mosquitoes. With the exception of this simple precaution, isolation and quarantine are of no avail.
3. Concurrent disinfection: None. Destruction of *Anopheles* mosquitoes in the sick room.
4. Terminal disinfection: Destruction of *Anopheles* mosquitoes in the sick room
5. Quarantine: None.
6. Immunization: None. The administration of prophylactic doses of quinine should be insisted on for those constantly exposed to infection and unable to protect themselves against *Anopheles* mosquitoes. This is not in an exact sense prophylaxis but early therapeusis.
7. Specific therapy: Quinine bisulfate is preferred for routine treatment and "atebrin" is found by some to be equally reliable. Plasmochin seems to be specific for destruction of the adult sexual form of the parasite in æstivo-autumnal malaria and in conjunction with quinine for tertian and quartan infections.
8. Investigation of source of infection: Breeding places and house infestation by *Anopheles* mosquitoes should be sought for and larvæ and mosquitoes destroyed when and where possible. Carriers of the malarial microörganism, untreated, or inadequately treated, should be sought and brought under systematic therapy until the microörganism can no longer be found in their blood.

B. General measures.

1. Employment of known measures for destroying larvæ of anophelines and the eradication of breeding places of such mosquitoes.
2. Blood examination of persons living in infected centers to determine the incidence of infection.
3. Screening sleeping and living quarters; use of mosquito nets.
4. Killing mosquitoes in living quarters.
5. Education of the public as to the mode of spread and methods of prevention of malaria.

Plague (bubonic, septicæmic, pneumonic).

1. *Recognition of the disease.*—An acute infection running a rapid, severe course, often terminating fatally, and characterized by extreme weakness, high fever, buboes, severe general symptoms, and often accompanied by

subcutaneous hæmorrhage and pustules. The infecting microörganism is regularly found in the buboes and skin lesions, and in the pneumonic type of the disease in the sputum. Pneumonic plague gives the picture of a virulent septic pneumonia.

2. *Etiological agent.*—**Pasturella pestis** (*Bacillus pestis*).
3. *Source of infection.*—Blood of infected rodents and, in the pneumonic form, the sputum of human cases. The primary or indigenous source of the disease is the so-called "wild-plague", the animal reservoir among such rodents as the tarbigan of Manchuria, and the ground squirrel of California. Infection may reach man from these sources, or more often through the medium of the rat.
4. *Mode of transmission.*—Direct, in the penumonic form. In other forms the disease is generally transmitted by the bites of fleas (*Xenopsylla cheopis* and *Ceratophyllus fasciatus*), by which the disease is carried from rats to man, also by fleas from other rodents. Accidental, by inoculation.
5. *Incubation period.*—Commonly from 3 to 7 days, although occasionally prolonged to 8 or even 14 days.
6. *Period of communicability.*—Pneumonic type intensely communicable during acute symptoms. Bubonic type not communicable from person to person.
7. *Susceptibility and immunity.*—Susceptibility is general, particuarly to the pneumonic form. Natural immunity may exist but is rare. Lasting immunity almost always results from recovery from an attack of the disease. Artificial passive immunity of about 3 to 4 weeks' duration by antiplague serum, and active immunity of about 6 months' duration by vaccines may be relied upon.
8. *Prevalence.*—Very rare in North America and insular possessions, and only sporadic cases, from exposure to infection to ground squirrels in California. Endemic in ground squirrels in large areas on Pacific Coast. Occasionally found in rats trapped at seaports.
9. *Methods of control:*

   A. The infected individual, contacts, and environment:

      1. Recognition of the disease and reporting: Clinical symptoms, confirmed by bacteriological examination of blood, pus from glandular lesions, or sputum. Animal inoculation of material from suspected cases.
      2. Isolation: Patient in hospital if practicable; if not, in a screened room which is free from vermin.[3]
      3. Concurrent disinfection: Sputum and articles soiled therewith, in pneumonic type of the disease.
      4. Terminal disinfection: Thorough cleaning followed by fumigation to destroy rats and fleas.
      5. Quarantine: Contacts of pneumonic cases for 7 days.
      6. Immunization: Ordinarily not practicable.
      7. Investigation of source of infection: Search for human (in pneumonic) and rodent (in bubonic) sources to which patient is known to have been exposed, among wild rodents, and particularly the rat.

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[3] In plague pneumonia, personal prophylaxis to avoid droplet infection must be carried out by persons who come in contact with the sick. Masks of closely woven cloth with mica windows should be worn over the head and to the shoulders. A long gown and rubber gloves drawn over the sleeves of the gown should be provided. These articles should not be removed from the sick room until disinfected.

B. General measures:
   1. Extermination of rats and vermin by use of known methods for their destruction; destruction of rats on ships arriving from infected ports; examination of rats, ground squirrels, etc., in areas where the infection persists, for evidence of endemic or epidemic prevalence of the disease among them.
   2. Rat-proofing of buildings and elimination of breeding places and opportunities for the harboring and feeding of rats as a fundamental sanitary measure.
   3. Investigation of all deaths during epidemics with autopsy and laboratory examination when indicated.
   4. Handling of corpse under antiseptic precautions.

Typhus fever.

1. *Recognition of the disease.*—Whether in the classical and severe epidemic form of the louse-transmitted disease or in the mild flea-borne and sporadic type, the onset is variable, often being sudden and marked by headache, chills, fever, and general pains, and a macular eruption on the fifth or sixth day, toxæmia, and a quite definite course terminating in rapid lysis after 12 to 21 days. A positive Weil-Felix reaction is valuable as confirmation of the diagnosis.
2. *Etiological agent.*—**Rickettsia prowazeki, Rickettsia quintana**, and provisionally, **Rickettsia mooseri.**
3. *Source of infection.*—The only known source is the blood of infected persons or infected rats.
4. *Mode of transmission.*—The infectious agent is transmitted from man to man by lice (*Pediculus humanus* var. *corporis*) and from rat to rat or man by fleas (*Xenopsylla cheopis*).
5. *Incubation period.*—From 5 to 20 days, most often 12 days.
6. *Period of communicability.*—In the presence of lice, highly communicable until 36 hours have elapsed after the temperature reaches normal.
7. *Susceptibility and immunity.*—Susceptibility is general. One attack confers immunity, which is not always permanent.
8. *Prevalence.*—Widespread. Flea-borne typhus predominantly in late summer and fall; louse-borne predominantly in winter and spring. The case fatality of flea-borne typhus is 2 per cent, and of louse-borne typhus 20 to 40 per cent.
9. *Methods of control:*
   A. The infected individual, contacts and environment:
      1. Recognition of the disease and reporting: Cases should be promptly reported to the health authorities.
      2. Isolation: In a vermin-free room.
      3. Concurrent disinfection: Destroy all lice and louse eggs on the clothing or in the hair of the patient.
      4. Terminal disinfection: None.
      5. Quarantine: In the presence of lice, exposed susceptibles should be quarantined for 14 days after last exposure.
      6. Immunization: Methods not yet available for general application.
      7. Investigation of source of infection: Particular attention should be paid to patient's contact with rats, and with louse-infected persons or clothing.
   B. General measures: The elimination of rats.
   C. Epidemic measures: Delousing of persons, clothing, and premises.

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Yellow fever.

1. *Recognition of the disease.*—Clinical diagnosis usually rests upon sudden onset, fever, prostration, slow pulse in relation to body temperature, severe headache and backache, congestion of mucous membranes, black vomit, bleeding gums, and late jaundice, with brief duration of illness. Pronounced albuminuria and leucopenia are characteristic. A history of possible bites of infected mosquitoes is corroborative but absence of such or even failure to find *Aëdes ægypti* mosquitoes in the vicinity does not necessarily exclude the diagnosis. Almost symptomless and certainly unrecognizable cases of this infection occur among Negro races in Africa.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—The blood of infected persons.
4. *Mode of transmission.*—By the bite of infected *Aëdes ægypti* mosquitoes, and of a few allied species. (It is not yet certain that some other suctorial insect may not be capable of acting as the transmitter.)
5. *Incubation period.*—Three to six days, rarely longer.
6. *Period of communicability.*—First 3 days of the fever, possibly 4. High degree of communicability where infected mosquitoes abound and there are many susceptible persons.
7. *Susceptibility and immunity*—Recovery from an attack of the disease is regularly followed by immunity, apparently for life. There is no natural immunity. Artificial immunity may be developed by the use of convalescent serum. The duration of this is brief. Artificial active immunity may be developed by the use of modified living virus and human immune serum. The duration of this is uncertain but it apparently lasts for several years.
8. *Prevalence.*—Very rare in North America and insular possessions. Not known in the Pacific Basin. No case in North America or Puerto Rico for many years.
9. *Methods of control:*

   A. The infected individual, contacts, and environment:

      1. Recognition of the disease and reporting: Clinical symptoms.
      2. Isolation: Isolate from mosquitoes in a special hospital ward or thoroughly screened room. It is necessary that the room or ward should be freed from mosquitoes by fumigation, trapping, or highly responsible collection and destruction of the insects. Isolation necessary only for the first 4 days of the fever.
      3. Concurrent disinfection: None.
      4. Terminal disinfection: None, except for the purpose of destroying mosquitoes in the house occupied by the patient and in the nearest neighboring dwellings, usually best by gaseous fumigation.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Human carriers are not known to exist. Search for undiscovered mild and unreported cases of illness resembling yellow fever, and systematic testing of immunity in groups related in time and proximity to the case in question are of epidemiological importance. Search for the *Aëdes ægypti* mosquito and other species believed to be capable of transmitting the infection should be particularly

thorough in the vicinity of places of residence, work, or travel of known cases of the disease.

B. General measures:

1. Eliminate breeding of *Aëdes ægypti* mosquito throughout the community by organized service of inspection and sanitary control.
2. An inspection service for discovery of those ill with the disease is desirable whether the disease occurs in the classical, mild, or atypical form.

GROUP IV. DISEASES TRANSMITTED BY DIRECT CONTACT

Scabies.	Others, not discussed here:
Venereal diseases.	Impetigo contagiosa.
Ring worm.	Yaws.

Scabies (itch).

1. *Recognition of the disease.*—Observation of the characteristic interdigital burrows of the itch mite, its identification under a hand lens, or of the eggs scraped from the burrows.
2. *Etiological agent.*—**Sarcoptes scabiei**, the itch mite.
3. *Source of infestation.*—Persons harboring the itch mite on their skin in burrows, particularly between the fingers.
4. *Mode of transmission.*—Direct contact with infested persons and indirectly by use of underclothing, gloves, bedding, etc., of such persons.
5. *Incubation period.*—Merely the length of time for the itch mite to burrow under the skin and lay eggs and start the itching and scratching, all of which may occur within 24 to 48 hours of original infestation.
6. *Period of communicability.*—Until the itch mites and the eggs are destroyed.
7. *Susceptibility and immunity.*—These terms are not appropriate to this condition. Anyone may become infested and immediately reinfested.
8. *Prevalence.*—Wide-spread and occurring sporadically and in epidemics, especially where there is a low level of bodily cleanliness and neglect of personal and clothing hygiene.
9. *Methods of control:*

A. The infested individual, contacts, and environment:

1. Recognition of the disease and reporting: The condition should be reported to the school authorities if discovered in school children.
2. Isolation: Children should be excluded from school until disinfested. Persons should be denied common recreation and bathing facilities while infested.
3. Concurrent disinfestation: Care of body clothing and bedding until free from the infestation.
4. Terminal disinfestation: Underclothing and bed covering to be so treated by dry heat or washing as to destroy the mite and the eggs.
5. Quarantine: None.
6. Investigation of source of infestation: Search for unreported or unrecognized cases in companions or house or family mates of the infested individual.

B. General measures: Cleanliness of body and underclothing and bed covering especially.

Chancroid.

1. *Infectious agent:* **Hæmophilus ducreyii** (*Bacillus of chancroid*).
2. *Source of infection:* Pus and secretion from the chancroid itself.
3. *Mode of transmission:* By direct contact with infected persons. Almost invariably through sexual intercourse. Possibly in other ways. Indirectly as mentioned under syphilis.
4. *Incubation period:* Usually within 5 days; always within 10 days.
5. *Period of communicability:* During continuance of specific organism and lesion.
6. *Method of control:*
   (A) The infected individual and his environment—Same as for syphilis.
   (B) General measures—Same as for syphilis.

Gonorrhœa.

1. *Recognition of the disease.*—Occurring initially as an infection of one of the mucous membranes, most frequently of the genital tract, urethra in the male, the vaginal or uterine mucosa in the female, the disease develops as an acute or chronic process in adjacent or remote tissues, among the latter especially as arthritis and endocarditis. Relapsing and chronic inflammatory discharging condition at the site of original attack are common. Demonstration of the etiological agent in the lesions or discharges is the best and only certain diagnostic procedure. Specific antibodies may be demonstrated, and specific constitutional and local reactions can be provoked.
2. *Etiological agent.*—**Neisseria gonorrhœa** (*Gonococcus*).
3. *Source of infection.*—Discharges from lesions of inflamed mucous membranes and glands of infected persons, viz., urethral, vaginal, cervical, conjunctival mucous membranes, and Bartholin's or Skene's glands in the female and Cowper's and the prostate glands in the male.
4. *Mode of transmission.*—By direct personal contact with infected persons and indirectly by contact with articles freshly soiled with the discharges of such persons. In adults by sexual intercourse; in children by other personal and indirect contact with discharges.
5. *Incubation period.*—One to 8 days, usually 3 to 5 days.
6. *Period of communicability.*—As long as the gonococcus persists in any of the discharges, whether the infection be an old or a recent one. Readily communicated in sexual intercourse.
7. *Susceptibility and immunity.*—Susceptibility appears to be general, particularly of vaginal tract in young girls, and of conjunctiva in newborn. Acquired immunity does not occur generally, but some degree of transient local immunity may appear during infection. One attack and recovery does not protect against subsequent infection.
8. *Prevalence.*—Wide-spread in both sexes and at all ages, but most common among men from 18 to 40 years of age and among women at a little earlier age. Endemic, sporadic, and epidemic.
9. *Method of control*:
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms, confirmed by bacteriological examination or serum reaction.
      2. Isolation: When the lesions are in the genito-urinary tract, exclusion from sexual contact, and when the lesions are conjunctival exclusion from school or contact with children, as long as the discharges contain the gonococcus.

3. Concurrent disinfection: Discharges from lesions and articles soiled therewith.
4. Terminal disinfection: None.
5. Quarantine: None.
6. Immunization: None.
7. Investigation of source of infection: Each acute case should be traced to probable source of infection and appropriate control and treatment of this spreader of disease instituted. Males may continue to be carriers for a year or more; females for 2 to 3 years.

B. General measures:

1. Provision of accurate and early diagnosis, and careful treatment of infected persons, with due consideration for privacy of record, consistent with effective control of the patient, search for source of infection, and provision for following cases until cured.
2. Education in matters of sexual hygiene, particularly as to the fact that continence in both sexes at all ages is compatible with health and normal development.
3. Repression of commercialized prostitution, and associated use of alcoholic beverages, by police or other competent authority.
4. Restriction of advertising of services or medicines for the self treatment of sex diseases, etc.
5. Elimination of common towels and toilet articles from public places.
6. Use of prophylactic silver solution in the eyes of the newborn.
7. Personal prophylaxis should be advised to those who expose themselves to opportunity for infection, and made available for use immediately after sexual intercourse.
8. Exclusion of persons in the communicable stage of the disease from occupations involving contact with children.

Lymphogranuloma venereum (inguinale) and Climatic bubo.

1. *Recognition of the disease.*—Adenopathy, inguinal in male, pelvic in female, and history of exposure to venereal infection in tropics (climatic bubo) or in temperate climates. Natural infection limited to human beings, but experimentally transmissible to monkeys and mice, less readily to other species. Characterized by small herpetiform lesion of inoculation on external genitalia or uterine mouth (rarely in it), often transitory, followed by subacute or chronic adenitis and periadenitis, usually with multiple foci of suppuration; associated with constitutional symptoms, fever, prostration, loss of weight, rheumatic affections, and skin reactions. Clinical diagnosis may be confirmed by Frei antigen intradermal test.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—Discharges from lesions.
4. *Mode of transmission.*—Direct contact by skin and mucous membranes, almost exclusively in sexual relations with infected persons, or indirectly by articles soiled with discharges from the lesions of such persons.
5. *Incubation period.*—One to four weeks. Glandular enlargement follows the initial lesion in 1 or 2 weeks.
6. *Period of communicability.*—As long as there are open lesions upon skin or mucous membranes.
7. *Susceptibility and immunity.*—Susceptibility appears to be general. Immunity apparently does not follow an attack of the disease. There is no artificial immunity.

8. *Prevalence.*—Has been known for many years as an occasional venereal infection in the Negro quarters of cities in the United States and more commonly in tropical possessions. Is still a rare disease in northern cities and among whites. Widely prevalent in the tropics and common among inmates and clients of brothels in tropical seaports.
2. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms.
      2. Isolation: Exclusion of infected person from sexual contacts and from preparation and serving of food during period of communicability.
      3. Concurrent disinfection: Discharges and articles soiled therewith.
      4. Terminal disinfection: None.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Search should be made for case of origin, particularly among prostitutes and among persons of Negro race, and of former residence in tropical and subtropical areas.

   B. General measures:
      1. Education in matters of sexual hygiene, particularly as to the fact that continence in both sexes and at all ages is compatible with health and normal development.
      2. Repression of commercial prostitution and associated use of alcoholic beverages by use of police and other competent authority and control of living premises.
      3. Elimination of the use of common towels, cups, toilet articles, and eating utensils.
      4. Exclusion of persons in the communicable state of the disease from participation in the preparing and serving of food.
      5. Personal prophylaxis should be advised and made available for use immediately after sexual intercourse to those who expose themselves to opportunity to infection.

Syphilis.

1. *Recognition of the disease.*—A disease acquired by contact or transmission *in utero,* running a chronic course with local and constitutional manifestations, usually in a definite sequence although of infinite variety. The lesion is an infectious granuloma, similar to that seen in tuberculosis and leprosy, in the acquired disease usually on mucous or muco-cutaneous area of sexual contact. Confirmation of diagnosis is practicable and should be established in every instance by finding the spirochæte in the lesions or discharges or by positive serological findings.
2. *Etiological agent.*—**Treponema pallidum** (*Spirochæta pallida*).
3. *Source of infection.*—Discharges from the lesions of the skin and mucous membranes, the blood of infected persons, and articles freshly soiled with such discharges or blood in which the *Treponema pallidum* is present.
4. *Mode of transmission.*—By direct personal contact with infected persons and indirectly by contact with discharges from lesions or with the blood of such persons, by sexual intercourse chiefly, by kissing, by dental and other surgical or technical accidents, congenitally from syphilitic mother through the placenta.
5. *Incubation period.*—About 3 weeks, minimum 10 days, occasionally 6 weeks or longer.

6. *Period of communicability.*—As long as the lesions are open upon the mucous membranes or skin, but practically limited to the first 2 years of the disease.
7. *Susceptibility and immunity.*—Susceptibility is universal, especially when moist surfaces of infected and exposed persons are brought into direct contact. Natural or acquired immunity is not known to exist. One attack and recovery does not protect against subsequent infection.
8. *Prevalence.*—Widespread in all regions of the world, regardless of race, climate, or geography, or of sex or age. Prevalence varies from less than one-half of 1 per cent to 30 per cent and over of local population groups, averaging probably about 5 per cent of all the people of North America. Occurs in sporadic, local, or group epidemic, and commonly endemic form. Most commonly acquired by unmarried males between 20 and 40 years of age. Occurs in about 10 per cent of all pregnant women. Most frequent among Negroes.
9. *Methods of control:*
   A. The infected individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms, confirmed by microscopical examination of discharges and by serum reactions. Diagnosis is essentially a laboratory problem and treatment should never be instituted without laboratory confirmation.
      2. Isolation: Essential for noncooperative patients at least until surface lesions have healed. No person in the communicable stage of syphilis should be permitted to engage in occupations of personal service in which he or she may infect others with syphilis, such as those of nurse or nursemaid, domestic servant, barber, hairdresser, chiropodist, manicurist, bath attendant, masseur, wet nurse. Sexual intercourse should be specifially warned against and so far as possible prevented for persons with syphilis until declared to be free from infection by the physician responsible for treatment of the patient.
      3. Concurrent disinfection of discharges and of articles soiled therewith.
      4. Terminal disinfection: None.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Each case, particularly those cases of presumably recent origin, as the congenital form of the disease in infants, and first and second-stage cases of the acquired disease, should be traced to the probable source of infection, appropriate control and treatment of this spreader of disease instituted, and further exposed contacts examined for unsuspected or unreported cases.
   B. General measures:
      1. Provisions for accurate and early diagnosis and careful treatment of infected persons, with due consideration for privacy of record, consistent with effective control of the patient, search for source of infection, and provision for following cases until cured.
      2. Education in matters of sexual hygiene, particularly as to the fact that continence in both sexes and at all ages is compatible with health and normal development.

3. Repression of commercial prostitution and associated use of alcoholic beverages, by means of the police or other competent authority.
4. Restriction of advertising of services or medicines for self-treatment of sex diseases, etc.
5. Elimination of the use of common towels, cups, and toilet articles from public places.
6. Serological as well as clinical examination for syphilis should be part of the routine prenatal supervision of the expectant mother and if she is found to be infected, antisyphilitic treatment should be begun if possible before the end of the fifth month of pregnancy.
7. Personal prophylaxis should be advised and be made available for use immediately after sexual intercourse to those who expose themselves to infection.

Ringworm. (Of scalp, body, feet, and groin.)

1. *Recognition of the disease.*—Inspection of the scalp and other parts of the body for the characteristics of the local lesion. Identification of the fungus in the scrapings from the edges of the skin areas involved.
2. *Etiological agent.*—**Trichophyton,** or **epidermophyton.**
3. *Source of infection.*—Lesions on bodies of infected persons or articles of clothing carrying the fungus or its spores.
4. *Mode of transmission.*—Direct skin-to-skin contact with lesions of infected persons and indirectly by articles of wearing apparel or by surfaces contaminated by scurf or scalings or hair from lesions.
5. *Incubation period.*—Undetermined.
6. *Period of communicability.*—As long as the fungus or its spores can be found at the site of the lesions. Transmission is easy in ordinary conduct of home or recreational pursuits, particularly those carried out indoors.
7. *Susceptibility and immunity.*—Susceptibility general. There is relative immunity to scalp ringworm after 15 years of age.
8. *Prevalence.*—Wide-spread, varying with aggregation of people under conditions appropriate for spread, as at swimming pools. Foot ringworm more common in adults, and the body, face, and head form more so among children, more especially in warm weather.
9. *Methods of control*:

   A. The infected individual, contacts, and environment:

      1. Recognition of disease and reporting: All cases recognized on inspection of school children should be reported to school authorities.
      2. Isolation: Children and adults with marked cases of the disease should be excluded from privileges in gymnasium and at swimming pools. Exclusion from school may be desirable in cases of ringworm of the scalp. There are too many carriers of foot ringworm to make control of them at all practicable.
      3. Concurrent disinfection: Cleanliness of body and underclothing, especially socks
      4. Terminal disinfection: None.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Among school children medical inspection should be used to detect unreported cases. In gymnasia and buildings devoted to athletics, particularly swimming,

search should be made as a routine, to exclude cases from common facilities.

B. General measures:

1. Cleanliness of body and underclothing.
2. Prompt and persistent treatment of the lesions should be urged.
3. Protection of feet against contamination in showers and dressing rooms and areas used by people with bare feet.
4. The use of disinfecting solutions may prove useful in connection with common bathing and dressing rooms.

GROUP V. DISEASES OF LOWER ANIMALS WHICH MAY BE TRANSMITTED TO MAN

Rabies.
Trichinosis.
Others, not here discussed:
- Actinomycosis.
- Anthrax.
- Foot and mouth disease.
- Glanders.
- Malta fever.
- Tularæmia.

Rabies.

1. *Recognition of the disease.*—In the human being this acute, specific, rapidly fatal infection may not be recognized until a spasm of deglutition appears, unless the earlier and mild constitutional symptoms such as an expression of anxiety, paresthesias especially in or near the wound, and some paralysis have been looked for after the bite of a rabid animal. In the dog or other animal, recognizable symptoms are any unexplained change in behavior followed by excitability or paralysis, and death within 10 days of onset of symptoms. Verification of cause of death may be established by discovery of Negri bodies in nerve cells of brain or cord, or by animal inoculation.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—Saliva of infected animals, chiefly dogs.
4. *Mode of transmission.*—Inoculation of denuded tissue with saliva of infected animals, almost always by bites.
5. *Incubation period.*—Usually 2 to 6 weeks. May be prolonged to 6 months or even longer. Duration depends on virulence of saliva and on site of wound in relation to richness of nerve supply and directness of nerve path to brain.
6. *Period of communicability.*—For 15 days in the dog before the onset of clinical symptoms and throughout the clinical course of the disease. Only slightly communicable in man.
7. *Susceptibility and immunity.*—Susceptibility general. Natural immunity is not known to exist in man or among the animals subject to the disease. Prophylactic antirabic treatment of infected humans will prevent development of the disease, with rare exceptions, if the treatment is begun soon after the injury and the site of the wound is not extensive in the distribution of the facial nerve.
8. *Prevalence.*—Rare in man; more likely to occur in males than females and most often in persons under 20 years of age. World-wide distribution. Universally fatal in developed human cases. More prevalent among dogs and sometimes in wild carnivorous animals.
9. *Methods of control:*

A. The infected individual, contacts, and environment:

1. Recognition of the disease and reporting: Clinical symptoms, confirmed by the presence of Negri bodies in the brain of the

animal which has caused the injury, and by animal inoculations with material from the brain of such animal.

2. Isolation: None if the patient is under adequate medical supervision, and the immediate attendants are warned of possibility of inoculation by human virus.
3. Concurrent disinfection: Saliva of patient and articles soiled therewith.
4. Terminal disinfection: Thorough cleaning.
5. Quarantine: None.
6. Immunization: Preventive vaccination of the patient after exposure to infection by inoculation.
7. Investigation of source of infection: Search for the rabid animal and for any animals bitten by it. Carriers in animals are not known to occur.

B. General measures:

1. Detention and examination of dogs suspected of having rabies.
2. Immediate antirabic treatment of people bitten by dogs or by other animals suspected or known to have rabies, unless the animal is proved not to be rabid by subsequent observation or by microscopic examination of the brain and cord. The wound caused by any bite of a rabid animal should be treated at once to the depths with fuming nitric acid, with complete protection of the eye in the case of face bites.
3. Education in the care of dogs, especially directed to dog owners and the police, including advice against shooting of rabid or suspected animals in the head lest the laboratory examination of the brain be rendered difficult or impossible. Dog owners should be impressed with the serious implications of keeping dogs in densely built up cities.
4. Control of dog population by requiring annual license, provision for the impounding and the humane destruction of all unlicensed dogs, quarantine of all dogs in areas where rabid animals have run at large.

Trichinosis.

1. *Recognition of the disease.*—In human beings confined to persons who have eaten raw or insufficiently cooked fresh pork products, occasionally bear meat, and characterized by onset of variable intensity according to the amount of infested meat eaten and the abundance of the trichinæ in the meat. The symptoms of invasion may be mild or of severe gastro-intestinal disturbance. Muscle soreness or pain, œdema of face and eyelids, weakness and distress are accompanied by a marked eosinophilia. Microscopic examination of the stools for adult worms, and of teased specimen of deltoid muscle for suspected embryos is helpful. Occasionally examination of the uncooked pork will reveal the parasites.
2. *Etiological agent.*—Trichinella spiralis (*Trichina spiralis*).
3. *Source of infection.*—Uncooked or insufficiently cooked pork, rarely meat of other animals.
4. *Mode of transmission.*—Direct from meat to man through consumption of undercooked infected pork products.
5. *Incubation period.*—Variable; usually about 1 week.
6. *Period of communicability.*—Disease is not transmitted by human host to man.

7. *Susceptibility and immunity.*—Susceptibility is general. Neither natural nor acquired immunity is known to occur.
8. *Prevalence.*—World-wide, but uncommon. No selection by age, sex, race, region, season, or climate except as these affect the custom of eating the insufficiently cooked flesh of infested hogs or other animals.
9. *Methods of control.*
   A. The infested individual, contacts, and environment:
      1. Recognition of the disease and reporting: Clinical symptoms, confirmed by microscopical examination of blood for eosinophilia, and about the third week for encysted larvæ in muscle tissue.
      2. Isolation: None.
      3. Concurrent disinfection: Sanitary disposal of the fæces of the patient.
      4. Terminal disinfection: None.
      5. Quarantine: None.
      6. Immunization: None.
      7. Investigation of source of infection: Every effort should be made to trace each case to a definite or probable source of raw or undercooked pork. Where hogs are fed on, or have access to, human offal, and human beings eat insufficiently cooked fresh pork products, there is an endless sequence of infestation and reinfestation of hog and human.
   B. General measures:
      1. Inspection of slaughtered hogs for the detection of trichinosis (rarely found unless muscles are heavily infested).
      2. Thorough cooking of all pork products at a temperature of 160° F. or over.
      3. Refrigeration of pork at 5° F. for 20 days.
      4. Extermination of rats, especially around meat shops and slaughter houses and hog pens.
      5. Cooking swill and offal which is to be fed to hogs.

GROUP VI. MISCELLANEOUS DISEASES.

Chicken pox.	Tetanus.
Small pox.	Trachoma.

Chicken pox.

1. *Recognition of the disease.*—Clinical picture is of an acute disease with a slight fever, mild constitutional symptoms, and an eruption, maculopapular for a few hours, often not observed, vesicular lasting 3 to 4 days leaving a granular scab. Vesicles tend to be as abundant on the covered as on the exposed parts of the body, and frequently appear in different stages on the same region of the body.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—The infectious agent is presumably present in the lesions of the skin and of the mucous membranes; the latter, appearing early and rupturing as soon as they appear, render the disease communicable early, that is, before the exanthem is in evidence.
4. *Mode of transmission.*—Directly from person to person; indirectly through articles freshly soiled by discharges from an infected person.
5. *Incubation period.*—Two to three weeks.
6. *Period of communicability.*—Probably not more than 6 days after the appearance of the first crop of vesicles, and certainly not more than 10 days.

Especially communicable in the early stages of the eruption. One of the most readily communicable of diseases.

7. *Susceptibility and immunity.*—Susceptibility is practically universal among those who have not previously had the disease. An attack confers permanent immunity, with rare exceptions. Passive temporary immunity may be conferred by the use of convalescent serum from those recently recovered.
8. *Prevalence.*—Universal. Probably 90 per cent of persons have had the disease by the time they are 15 years of age. Not uncommon in early infancy. Winter and spring are seasons of greatest prevalence in North America.
9. *Methods of control:*
   A. The infected individual, contacts and environment:
      1. Recognition of the disease and reporting: The chief public health importance of this disease is that cases thought to be chicken pox in persons over 15 years of age, or at any age during an epidemic of smallpox, are to be investigated to eliminate the possibility of their being smallpox.
      2. Isolation: Exclusion from school, and avoidance of contact with nonimmune persons should be made effective.
      3. Concurrent disinfection: Articles soiled by discharges from lesions.
      4. Terminal disinfection: Thorough cleaning.
      5. Quarantine: None.
      6. Immunization: Passive immunization of susceptible children may be of value in institutions when exposure is feared, or under exceptional conditions in individual cases.
      7. Investigation of source of infection: Of no importance unless in persons over 15 years of age or when smallpox is suspected or is locally prevalent.

   B. General measures: None.

Smallpox.

1. *Recognition of the disease.*—One to five days of febrile symptoms before the eruption, which is papular for 1 to 4 days, vesicular for 1 to 4 days, and pustular for 2 to 6 days, forming crusts which fall off 10 to 40 days after the first sign of the lesions, and leave pink scars which fade gradually. Unless scanty, the eruption is symmetrical and general, more profuse on prominences, extensor surfaces, and surfaces exposed to irritation, than on protected surfaces, flexures, and depressions. Most abundant and earliest on the face, next on forearms, wrists, and hands, favoring the limbs, especially distally, more than the trunk. More abundant on shoulders and chest than on loins or abdomen, but the lesions may be so few as to be overlooked. The individual lesions are deep-seated and have an infiltrated base, except when modified naturally or by previous vaccination. Any case of purpura or hæmorrhage into the skin with fever should be treated with smallpox precautions until another diagnosis is clear.
2. *Etiological agent.*—A specific filtrable virus.
3. *Source of infection.*—Lesions of the mucous membranes and skin of infected persons.
4. *Mode of transmission.*—By contact with persons sick with the disease. This contact need not be intimate, but aerial transmission through more than a few feet is unlikely; by articles or persons contaminated by discharges of the sick, including fæces and urine, but for a brief time.
5. *Incubation period.*—Eight to sixteen days. (Cases with incubation period of 21 days are reported.)

6. *Period of communicability.*—From first symptoms to disappearance of all scabs and crusts.
7. *Susceptibility and immunity.*—Susceptibility universal. Acquired permanent immunity usually follows recovery from an attack of the disease. Second attacks are rare. Artificial immunity by vaccination is usually complete for 5 to 20 years, but relative susceptibility often occurs after 5 years.
8. *Prevalence.*—Distribution in sporadic or epidemic form; varies widely according to the immunity status of the population of an area and its exposure to infection from without. Cases occur most often in young adult males. Occurrence is most frequent in the winter and least in summer months. There is no regional or climatic limitation to its prevalence except as population groups are more or less well protected by vaccination.
9. *Methods of control:*
   - A. The infected individual, contacts, and environment:
     1. Recognition of the disease and reporting: Clinical symptoms. The rapidly fatal or fulminating type and the very mild type may escape diagnosis until secondary cases appear.
     2. Isolation: Hospital isolation in screened wards, free from vermin, until the period of infectivity is past.
     3. Concurrent disinfection of all discharges: No article to leave the surroundings of the patient without boiling or equally effective disinfection.
     4. Terminal disinfection: Thorough cleaning and disinfection of premises.
     5. Quarantine: Isolation of all contacts until vaccinated with virus of full potency, and daily medical observation of these contacts until height of reaction is passed, if vaccination was performed within 24 hours of first exposure; otherwise for 16 days from last exposure.
     6. Immunization: Vaccination.
     7. Investigation of source of infection: The immediate prior case should be sought industriously, and cases of reported chicken pox associated in time or place carefully reviewed for error of diagnosis. Active cases of the disease without remaining constitutional symptoms must be sought, also passive carriers recently in contact with cases, and exposed vaccinated persons who may have developed unrecognized forms of the disease, and thus be serving as sources of infection.
   - B. General measures:
     1. General vaccination in early infancy, revaccination of children on entering a school, and of entire population when the disease appears in a severe form.
     2. In order to avoid possible complications or secondary and subsequent infections at the site of vaccination, it is important that the vaccination insertion be as small and superficial as practicable, not over one-eighth inch in any direction, and that the site be kept dry and cool. The use of shields or other dressings is to be condemned. The multiple pressure method is recommended. Primary vaccination as soon after 1 week of age as possible is desirable. The time of vaccination should be adjusted to avoid skin lesions elsewhere on the body, and in older children to avoid the warmer months. Particular care should be used in primary vaccinations beyond the age of infancy.

10. *Method of vaccination.*—The best method of vaccination is probably the "multiple pressure" method as recommended by the United States Public Health Service. This method consists of pressures against the cleansed but not irritated skin with the side of a needle point, through a drop of smallpox vaccine, covering an area not more than one-eighth of an inch (3 millimeters) in its greatest diameter. This gives very superficial implantation and the eruption is typical. The skin of the left upper arm, over the insertion of the deltoid muscle, is the standard site for vaccinating, and has some advantages over any other. Acetone has been

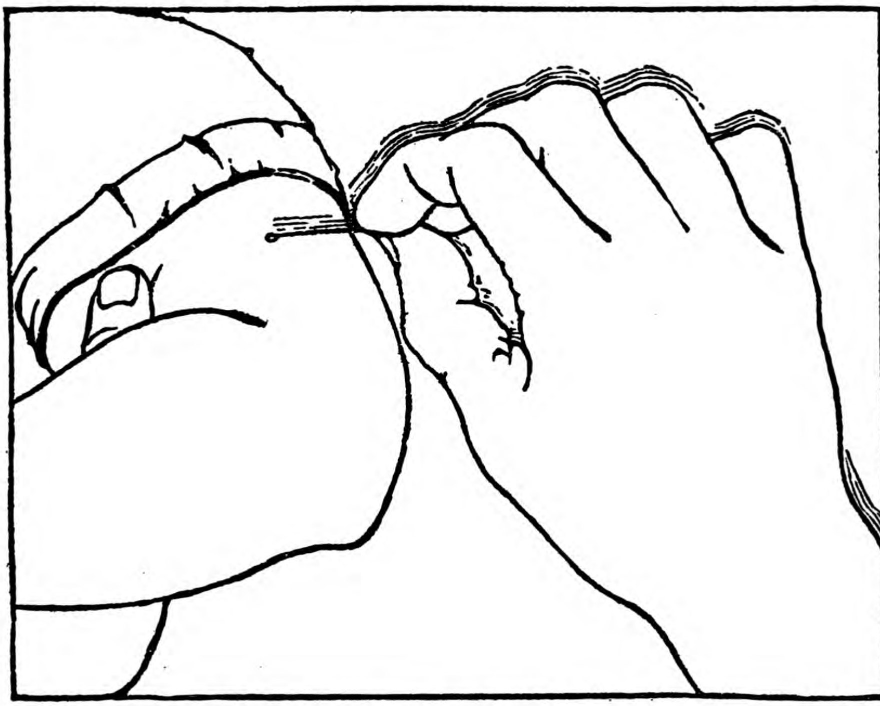

FIGURE 121.—The "multiple pressure" method of vaccination, showing the rapid up-and-down motion of the side of the needle, held by the hand at the right, against the drop of vaccine on the arm at the left. It is not necessary to hold the skin taut with the operator's left hand as is done in other methods of vaccination. (U. S. Public Health Reports.)

found satisfactory for cleansing the skin. It is somewhat more efficacious than alcohol and evaporates more rapidly. The needle, which should be new, sharp, and sterile, is not thrust into the skin, but is held quite parallel or tangential to it, with the forefinger and middle finger of the right hand above the needle and the thumb below, the needle pointing to the operator's left. (*See* fig. 121.) The needle should be crosswise of the arm, so that the thumb of the operator is not impeded by hitting the skin. The *side* of the needle point is then pressed firmly and rapidly into the drop about 30 times within five seconds (or not more than 10 times for primary vaccinations with highly potent vaccine) the needle being lifted clear of the skin each time. This rapid up-and-down motion of lifting the needle and pressing it against the skin should be quite perpendicular to the skin and needle and not in the direction of the long axis of the needle. The point is not driven into

the skin, but at each pressure the elasticity of the skin will pull a fraction of a millimeter of the epidermis over the point of the needle so that the vaccine is carried into the deeper layers of the epidermis, where multiplication takes place most easily.

If the skin has not been unduly rubbed in cleansing, and if the pressure is entirely perpendicular to the needle, no signs of bleeding should occur and all evidence of the trauma will be gone in a few hours. Immediately after the pressures have been made, the remaining vaccine is gently wiped off the skin with sterile gauze and the sleeve pulled down.

11. *Interpretation of results of vaccination.*—PRIMARY REACTION: With the typical primary vaccination, indicating absence of immunity to smallpox prior to this vaccination, the zone of redness, rather narrow from the third to the seventh day, begins a sudden spread about seven days after vaccination, and reaches its broadest diameter in 8 to 14 days after vaccination, rapidly disintegrating and disappearing thereafter.

ACCELERATED REACTION: With the accelerated or modified vaccination reaction indicating a partial immunity, the broadest redness is reached and passed in three to seven days after vaccination.

IMMUNE REACTION: In this reaction which indicates full protection against smallpox, the broadest redness is reached and passed in 8 to 72 hours after vaccination. This redness is accompanied by a slight elevation of the skin, which can be felt by passing the fingers lightly over the vaccinated area.

The sharp division of the postvaccinal reaction into these three types (immune reaction, vaccinoid, and primary vaccinia) is somewhat arbitrary, all gradations being found in practice; strictly speaking, all three reactions are forms of vaccinia; *differentiation into the three types is based on the time of broadest redness.* Therefore, a single observation is not sufficient to tell, for example, whether a vaccination has resulted in a reaction of immunity or in a vaccinoid. It is not the time of appearance of the reaction but the time when the areola is at its maximum that forms the basis of differentiation. The more prompt the maximum the greater was the previous immunity. The size and intensity of the reaction, and to some extent its time relations, are dependent also on individual (or familial) predisposition as well as on the vaccine and method of insertion. Such variations in the reaction are subsidiary to the three types classified by immune status.

12. *Storage of smallpox vaccine.*—Icebox refrigeration is not cold enough for this purpose. Smallpox vaccine, formerly called vaccine virus, cannot be injured by freezing, as can serums and other vaccines. Even a single day out of cold storage, in addition to the necessary transportation from the manufacturing laboratory, may produce detectable deterioration in potency. Smallpox vaccine which has been out of cold storage so that it gives only about 80 per cent or 90 per cent of successful vaccinations on previously unvaccinated individuals is not satisfactory and may be dangerously weak in the presence of severe smallpox. When reactions of immunity are to be observed, the vaccine should be obtained direct from the manufacturer and kept below freezing. For all vaccinations, vaccine of full potency should be used, so that the insertions may be as small and superficial as possible, yet success be assured in every vaccination. Weakness of vaccine has in the past been the reason for dangerously large insertions. Vaccine should be of uniformly high potency, but not too strong. Though other factors than temperature are concerned

in potency, it is possible that improvement in refrigeration practice in America has been one of the chief agents in recent reductions in the incidence of smallpox and of vaccination mishaps.

In an electric refrigerator the smallpox vaccine should be kept in an ice-making compartment. Next best to storage below freezing is placing the vaccine in a metal or glass container in constant contact with ice or with the freezing chamber. If a vacuum bottle is used for transporting smallpox vaccine, the inside of the bottle should be packed with ice around the vaccine. The packages in a pharmacy are best stored in a wide-mouth rubber-stoppered bottle fitting loosely inside the cooling unit of a mechanical refrigerator, which should be defrosted just before the packages are received, rather than after. Other biologic products are less sensitive to heat but are sensitive to freezing and should not be stored in this way. The stoppered bottle prevents maceration of the labels and rusting of the needles caused by moisture condensing when the door is opened. If this protection is impossible, a memorandum should be made of the lot number and the expiration date, lest the stamping of the package become illegible, and the needles should be removed unless they are in glass-sealed tubes.

Tetanus.

1. *Recognition of the disease.*—An acute infectious disease caused by the toxin of the tetanus bacillus; characterized by painful muscular contractions, first and principally of the masseter and neck muscles, and secondly those of the trunk; rarely the rigidity is confined to the region of the injury. A history and usually physical evidence of a wound of entry for infection is found. Bacteriological examination and mouse inoculation may be useful in confirmation of diagnosis.
2. *Etiological agent.*—**Clostridium tetani.** *(Bacillus tetani).*
3. *Source of infection.*—Animal manure, human fæces, soil, and street dust.
4. *Mode of transmission.*—Wound infection.
5. *Incubation period.*—Commonly 4 days to 3 weeks, dependent somewhat upon the character, extent, and location of the wound. Longer periods of incubation have been noted. Subsequent operative interference or local tissue changes may initiate the activity of quiescent bacilli at even lengthy intervals after the original wound infection.
6. *Period of communicability.*—Patient not infectious except in rare instances where wound discharges are infectious.
7. *Susceptibility and immunity.*—Susceptibility general, but inoculated bacilli often fail to produce toxin. Artificial passive immunity for about 10 days' duration can be relied upon from the use of tetanus antitoxin. An active immunity may be produced by the use of tetanus toxoid.
8. *Prevalence.*—World-wide distribution, following wound infection. Most frequent in North America among young males and in summer. Prevalent especially following wounds contaminated with manured soil.
9. *Methods of control:*

   A. The infected individual, contacts, and environment:

   1. Recognition of the disease and reporting: Clinical symptoms may be confirmed bacteriologically.
   2. Isolation: None.
   3. Quarantine: None.
   4. Immunization: Ordinarily a subcutaneous injection of tetanus antitoxin (1,500 units) given on the day of the wound. A second injection within 10 days may be desirable in certain instances.

5. Investigation of source of infection: Of only academic interest, as the infecting organism is widely spread, especially through animal fæces, in all inhabited places.
6. Concurrent disinfection: None.
7. Terminal disinfection: None.

B. General measures:

1. Educational propaganda such as "safety first" campaign, and "safe and sane Fourth of July" campaign.
2. Prophylactic use of tetanus antitoxin where wounds have been acquired in regions where tetanus is prevalent, and in all cases where contaminated material may be embedded in the wound.
3. Removal of all foreign matter as early as possible from all wounds.

Trachoma.

1. *Recognition of the disease.*—A specific destructive chronic inflammation of the conjunctiva, characterized by formation of granulations, either papillary or follicular, leading ultimately to formation of scar tissue and deformity of the eyelids. Microscopic examination of the conjunctival discharges and scrapings cannot be relied upon as an aid to diagnosis, but may exclude other infections.
2. *Etiological agent.*—Undetermined.
3. *Source of infection.*—Secretions and purulent discharges from the conjunctivæ and adnexed mucous membranes of the infected persons.
4. *Mode of transmission.*—By direct contact with infected persons and indirectly by contact with articles freshly soiled with the infective discharges of such persons.
5. *Incubation period.*—Undetermined.
6. *Period of communicability.*—During the persistence of lesions of the conjunctivæ and of the adnexed mucous membranes or of discharges from such lesions.
7. *Susceptibility and immunity.*—Susceptibility is general, greater in children than in adults and increased by malnutrition, chronic irritation by dust, wind, exposure to the sun, and by carelessness of personal cleanliness. Natural or acquired immunity is not known to occur.
8. *Prevalence.*—Not uncommon in immigrants from southern and eastern Europe. Incidence high among mountain population of southern Appalachians, and to an extent of 5 to 25 per cent among plains and Pueblo Indians of the United States. In Canada the main focus is in southern Manitoba; rare in white, native born Canadians; in Indians, cases are distributed from Ontario westward through the prairie provinces and into British Columbia. Cases most common among children but may occur and persist at any age.
9. *Methods of control:*

A. The infected individual, contacts, and environment:

1. Recognition of the disease and reporting: Clinical symptoms.
2. Isolation: Exclusion of the patient from general school classes. Isolation of the patient is not necessary if he is properly treated and instructed in precautions against spread of secretions of the eye to others by common use of articles.
3. Concurrent disinfection of discharge and articles soiled therewith.
4. Terminal disinfection: None.
5. Quarantine: None.
6. Immunization: None.

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7. Investigation of source of infection: Careful search should be made of persons in any way intimately related or exposed to the patient, particularly members of the household, and playmates and schoolmates. Carriers are not known to occur, but apparently healed scars of old lesions may be the site of reactivity and becomes sources of infection.

B. General measures:

1. Search for cases by examination of school children, or immigrants, and among the families and associates of recognized cases; in addition, search for acute secreting disease of conjunctivæ and adnexed mucous membranes, both among school children and in their families, and treatment of such cases until cured.
2. Elimination of common towels and toilet articles from public places.
3. Education in the principles of personal cleanliness and the necessity of avoiding direct or indirect transference of body discharges.
4. Control of public dispensaries where communicable eye diseases are treated, and creation of special treatment classes where the disease prevails.
5. Exclusion of infected immigrants at national boundaries, or preferably at foreign ports of embarkation.
6. Routine examination of eyes of children admitted to institutions, or in industrial camps where the disease is prevalent.
7. Under certain conditions in areas of widespread prevalence of the disease, the prophylactic use of solutions of zinc sulfate (1 per cent) or copper sulfate (0.5 per cent) may prove a valuable protective measure for children.

PRACTICAL HYGIENE AND SANITATION

Air, ventilation, heating, lighting, and housing.

Air is one of the absolute necessities of life and it has been aptly said that man lives at the bottom of a vast ocean of air. It is not a fixed chemical compound but a mixture of gases, and its chemical composition is practically uniform the world over. In normal atmospheric air the percentages of the different gases are approximately as follows: Oxygen, 21; nitrogen, 78; carbon dioxide, 0.03; argon, 0.94; and traces of helium, krypton, neon, xenon, hydrogen, hydrogen peroxide, ammonia, and ozone. In addition to the gases named there is present in the air varying amounts of water vapor, and there are suspended in the air such particles as dust, bacteria, yeasts, etc.

In relation to health, air affects the physiological functioning of the body in two ways, the interchange of gases in respiration and the regulation of body temperature.

Of the gases present in air only a few are considered to be of physiological importance. While nitrogen is of the most vital importance in the composition and functioning of the body, the nitrogen found in the air serves only as a diluent of the oxygen present. The body gets its nitrogen from the proteins in the food eaten.

Oxygen is the vital gas in the atmosphere. It is necessary for all forms of animal life. It passes through the very thin walls of the air sacs of the lungs into the blood, where it is taken up by the hæmoglobin, is carried back

to the heart and pumped to all parts of the body where it oxidizes or burns up the food with the production of the heat and energy necessary to carry on the normal body processes. The excess of oxygen unites with waste carbon dioxide and water. These are carried back to the lungs by the venous blood and are taken from the body by the breathed-out air. If the oxygen in the air falls below 16 per cent, distress follows; if it falls below 12 per cent, slow death occurs.

The small amount (0.03 part) of carbon dioxide found in atmospheric air is of no sanitary importance. It is not poisonous outside of the body, but being a waste product constantly being breathed out by all forms of animal life, its presence in increased amounts indicates pollution of the air and poor ventilation. A certain amount of carbon dioxide is necessary for the body as, by its presence in the blood, the action of the heart is regulated and the respiratory center stimulated.

Carbon monoxide is a colorless, odorless, and tasteless gas not normally present in the atmosphere. It is a by-product of incomplete combustion and is present following explosions of gunpowder, in illuminating gas, in coal gas, and in the exhaust from gasoline engines. With the increasing use of the automobile with its gasoline engine, carbon monoxide is increasing in sanitary importance. Wherever gasoline engines are used there should be abundant ventilation. Carbon monoxide acts as a poison by uniting and forming a fixed compound with the hæmoglobin of the blood. Death results when there is insufficient free hæmoglobin remaining to carry an adequate supply of oxygen to the body cells.

The chief physical properties of air are temperature, humidity, movement of the air, and atmospheric pressure. Formerly the discomfort and ill effects suffered in crowded, ill-ventilated rooms were thought to be due to the presence of increased amounts of carbon dioxide breathed out by the occupants. It is now believed to result from increased temperature and humidity, and a lack of air movement consequent upon inadequate ventilation. Bodily comfort is largely dependent upon the constant elimination of the excess heat formed during metabolism, and the maintenance of the "normal" body temperature of about 98.6° F. This is accomplished in a condition of health through the functioning of the heat-regulating center in the medulla oblongata. Heat is dissipated from the body chiefly through radiation, conduction, convection, evaporation, and respiration. By *radiation* is meant the emanation of heat directly from a heated object, as in the case of a steam radiator. By *conduction* is meant the transmission of heat to a contiguous substance, as when a red-hot poker is put into water the poker is cooled and the water heated. By *convection* is meant the carrying away of the heat radiated by the body. Heat is lost by *evaporation* of perspiration, the process of evaporation abstracting heat from the body with consequent cooling. When one becomes overheated the heat regulating center goes into action, sending the hot blood to the surface of the body where some of the excess heat is radiated and conveyed away; and perspiration, and respiration are accelerated. The relation of these physiological functions to the physical properties of the air, temperature, humidity, and movement will now be discussed.

The human body possesses wide powers of adaptability to varying degrees of *temperature*. Man lives in all climates and labors under diverse conditions of temperature. These conditions are modified largely by clothing, food, housing, artificial heating, cooling, and by the heat-regulating center of the body. When many persons are closely associated and the ventilation is poor the heat radiated by their bodies causes a rise of temperature. Discomfort

increases as the room temperature approximates that of the body, preventing as it does loss of heat by radiation.

Humidity influences the output of heat from the body in two ways. It increases the conductivity of the atmosphere for heat, a cooling influence, and hence cold moist air is chilling, and it interferes with the evaporation of perspiration, a heating influence, and hence warm moist air is enervating. At a temperature of about 68° F. humidity has comparatively little effect. Relative humidity is a term generally used to express the amount of moisture in the air and means the amount of moisture present at the time the observation is made, relative to the amount of moisture required at that same temperature to completely saturate the air.

The amount of moisture present (relative humidity) in the air affects the body by controlling the rate of evaporation of perspiration from the skin. The greater the relative humidity the less moisture the air can absorb, and hence the slower will be the evaporation of perspiration. For example, on the hot, "humid" days in summer there is high relative humidity, though not always necessarily a high temperature. If the air is dry (low relative humidity) as found in desert and mountainous regions, one can stand high temperatures without great distress. Conversely the same thing applies in cold weather, the greater the relative humidity the more one will mind the cold, the moisture in this case acting as a rapid conductor of heat away from the body. The relative humidity is often referred to as the *drying power* of the air; when the humidity is high the drying power is poor, there already being a high percentage of moisture in the air. When the relative humidity is low, the drying power is high—the air being able to take up a great deal of moisture.

The movement of air is one of the factors which determine the degree of comfort under various atmospheric conditions, even when the temperature and relative humidity are high. A layer or blanket of hot, moist air collects in the meshes of the clothing about the body. The moving air blows this away and mixes it with the air in the room, thus cooling and relieving the body. The movement of air associated with minute changes in temperature has a distinct stimulatory effect on the heat regulating center of the body and explains the comfort produced by an oscillating fan. Men placed in carefully controlled chambers where the conditions of overcrowded, badly ventilated rooms were produced (increased relative humidity and heat; oxygen reduced to 16 or 17 per cent and the carbon dioxide increased to between 3 and 4 per cent), suffered even when breathing pure fresh air through tubes from without the chamber; while men who were outside the chamber under conditions where the excess heat and moisture produced by their bodies were quickly dissipated, experienced no discomfort when breathing the polluted air from within the chamber through tubes. These experiments proved that under ordinary conditions discomfort does not result from decreased oxygen or increased carbon dioxide, but because the body cannot eliminate the excess waste heat. Discomfort, symptoms of heat exhaustion or heat stroke, and what is called "crowd poisoning," result under the following conditions, which constitute a summary of the foregoing discussion of the effects of the physical properties of air:

1. When the temperature is so high that the body cannot eliminate its excess heat;

2. When the relative humidity is so high that perspiration cannot be evaporated from the surface of the body with a consequent cooling effect; and

3. When there is no movement of air to remove the hot, moist blanket of air which accumulates about the body, and stimulates the heat-regulating center in the medulla.

The normal *atmospheric pressure* at sea level is 15 pounds to the square inch which is really the weight of a column of air 1 inch square at its base and as high as the air extends. An average man at sea level is subjected to an air pressure of more than 15 tons. Regardless of the elevation at which one lives the pressure of the gases in the body tissues is in equilibrium with the gases surrounding the body. With sudden changes in atmospheric pressure certain changes and symptoms are produced in the body by the effort of the gases inside the body, principally nitrogen, to come into equilibrium with the atmospheric pressure outside, and also because the atmospheric content of oxygen per cubic foot decreases with the pressure and vice versa.

The effects of increased atmospheric pressure on health.—Men in the Navy are subjected to increased pressure in deep-sea diving. The normal air pressure at sea level of 15 pounds per square inch is spoken of as 1 atmosphere. Every depth of 10 meters increases the pressure 1 atmosphere and at a depth of 30 meters (about 100 feet) a diver is exposed to a pressure of 4 atmospheres, or about 60 pounds to the square inch. The symptoms attendant upon increasing pressure and consequent absorption of increased amounts of gases in the tissues are not marked. It is when the pressure is suddenly decreased as when a diver is brought to the surface too quickly, that the dangerous symptoms known as *caisson disease* occur. These are due to the release of the accumulated gases in the tissues and body fluids when the pressure is suddenly decreased. The gases tend to form bubbles, and it is the escape of these bubbles through the tissues and capillary walls that causes the distress. The symptoms of caisson disease are excruciating pain in the muscles and joints, called "bends"; hæmorrhages from the nose and ears; paralysis, unconsciousness, and even death from the plugging of blood capillaries by air bubbles, and hæmorrhages into the brain and spinal cord. The disease is prevented by gradual decompression of persons under increased pressures, i. e., bringing them to the surface slowly. If suffering when brought to the surface, the victim should be placed in a compression chamber such as is available in diving operations, and decompressed slowly.

The effects of decreased atmospheric pressure upon health.—The symptoms of decreased pressure (known as mountain or aviator's sickness) are due to the rarefied air, as well as to the decreased pressure, and come on when ascending high mountains or ascending in aircraft. The noticeable symptoms are: Increase in the respiration; noises in the head and dizziness; impairment of the senses of sight, hearing, and touch; dullness of the intellectual faculties, and a strong desire to sleep. Consciousness is lost at the altitude of about 26,000 feet. The prevention of mountain sickness consists of keeping warm, avoidance of muscular exertion, inhalations from an oxygen tank, and gradual ascent into rarefied atmosphere.

While often very offensive to one's sense of smell and at times even nauseating, *odors* produce no other harmful effects, unless they are poisonous gases.

In the open air there is very little danger from the *microörganisms* that cause disease in man. They require a suitable temperature (that of the body), moisture, and a food supply of body fluids or tissues to retain their virulence or power to cause disease. All of these are lacking under outside conditions where microörganisms also are affected adversely by sunlight. In close proximity to others and within buildings under crowded, poorly-ventilate conditions the danger from microörganisms in the air is very great. Per are constantly spreading bacteria by coughing and sneezing as well spitting on the decks and floors. The communicable diseases transr the nose and mouth discharges are largely spread by these means.

should be taken to never cough or sneeze in the presence of other persons without first covering the mouth and nose.

Dust in wide open spaces is of relatively little importance as a cause of disease. As previously pointed out, pathogenic microörganisms do not find the conditions necessary for life in the outside air and quickly die. Within rooms and compartments (particularly hospital wards and sick bays) dust may be dangerous because of expectoration and microörganisms coughed or sneezed into the air. Care should be exercised in sweeping and dusting, to raise as little dust as possible. Industrial dust, or that arising in connection with manufacturing or repair work is a serious problem. Such dust is classed as *hard* and *soft*, according to its composition and abrasive qualities. Bits of steel and other sharp, hard fragments injure the eyes and exposed parts of the body. Goggles, masks, and gloves are preventives. When inhaled, dust lodges and accumulates in the lungs, causing disease conditions, as well as predisposing to pulmonary tuberculosis and other respiratory diseases. Use of respirators is the chief preventive measure.

Ventilation is the process by which the air of compartments which has become vitiated by human and animal occupancy or manufacturing processes and machinery is diluted and replaced by fresh air of proper chemical and physical composition.

Satisfactory ventilation should:

1. Dilute and replace polluted and vitiated air in compartments with pure air from without,

2. Maintain a temperature within the compartment of from 60° to 72° F., according to the activity of the occupants; and a relative humidity of about 50.

3. Keep the air in a gentle continuous motion.

Any system of ventilation should supply each occupant with between 2,500 and 3,000 cubic feet of pure air per hour. A properly designed system will allow six complete changes of air each hour. Ventilation methods are classified as *natural* and *artificial.* Inasmuch as ventilation in the Navy has to be carried out ashore and also on board ship, the methods applicable in each case will be considered separately.

Natural ventilation ashore is carried out by the proper manipulation of windows, doors, transoms, and other openings admitting fresh air from without. Such openings are best situated on opposite sides of the rooms and may be assisted by window ventilators, ridge ventilators, etc.

Artificial ventilation ashore is carried out much the same as on board ship (discussed later).

As in buildings natural ventilation of ships takes place through all openings in the sides of ships and those leading from the "top side" to the decks below. It may be assisted by using scoops in air ports, windsails, and screens.

Artificial ventilation of ships and buildings is accomplished by the use of blower fans of which there are two types: 1. Supply blowers which suck in fresh air and force (supply) it to compartments; and 2. Exhaust blower fans, which suck out or exhaust highly polluted air from compartments.

There are three systems of artificial ventilation: 1. The supply or plenum; 2. The exhaust; and 3. A combination of the supply and exhaust systems.

The *plenum* or *supply system* is that by which fresh air is sucked in from without and propelled by fans through ducts to the places it is needed. The intake should be located at a point where the least smoke, dirt, or odors will be taken in. Frequently the air is washed, humidified, and heated in connection with the supply system. This is the most generally used system of ventilation and operates on the theory that the fresh air supplied will force out and

replace the polluted air, which escapes through the natural openings of the ship or building.

The *exhaust system* of ventilation is the reverse of the supply system, and is used only where there is great pollution of the air, as in the "heads," certain storerooms, the engine and fire rooms, culinary department, and the magazines. It is used extensively in connection with manufacturing to draw off dust, odors, and poisonous gases and discharge them into the outside air.

The *combined supply and exhaust system* is used where fresh air is needed and foul air must be gotten rid of. This system is generally used in sick bays afloat.

In testing the efficiency of ventilating systems the air of various parts of the compartments should be examined as to its carbon dioxide content, its humidity and drying power determined by the psychrometer, movement determined by the anemometer, and its odor noted. Polluted air generally has a bad odor. A very simple and practical method to determine the movement of air is by means of lighted candles or the smoke from burning cigarettes. Pockets of stagnant air can be relieved readily by an electric fan.

There are three methods in common use for heating compartments or rooms: 1. *Direct heating*, effected by radiators, stoves, open fires, etc., in which the heat rays progress directly from their source; 2. *Indirect heating*, effected by supplying to the compartment air previously heated elsewhere, as by hot-air furnaces or by a thermo-ventilation system; and 3. *Direct-indirect heating*, effected by a combination of the two foregoing methods, in which part of the heat is supplied by warm air entering the room and part by radiators or stoves in the room.

Most barrack buildings on shore, and the older ships of the Navy as well as the modern smaller ships are heated by the direct system. In the modern capital ships the indirect system, or the direct-indirect system, is used; the air also is humidified.

Regardless of what heating system is used, living rooms and compartments should be kept at a temperature of about 65° to 72° F., and a relative humidity of about 50. When the indirect system of heating is used precautions must be taken to supply sufficient humidity or moisture to the air. This can be accomplished by passing the air through a steam chamber or in the case of hot-air furnaces by evaporation from a pan of water within the furnace.

The artificial cooling of air is used more extensively each year. It is effected by passing air through a cold-spray chamber or by substituting cold coils for the hot coils used in conditioning the air in a combined heating and ventilating plant. It is used particularly where there are overcrowded conditions in hot weather, as in theaters, and where conditions would be otherwise unbearable. It is logical to suppose that with the perfection of "air cooling," it will be used on naval vessels designed for tropical service; and also the parts of ships where the heat becomes so excessive as to endanger health and life. Artificial cooling is already used aboard submarines. Fans are great aids to artificial cooling.

Light may be natural, that emanating from the sun, or artificial, that produced by various kinds of illuminants, such as gas, oils, electricity, etc. Natural light provides illumination, and also has certain marked stimulatory effects on all forms of life processes. Artificial light is generally used for illuminating purposes, but some forms, such as ultra-violet and X-rays have marked chemical and therapeutic effects and are used in medicine and science. Colored lights influence the emotions, green being neutral and soothing, while red and violet are stimulating.

Natural light is made up of energy given off from the sun and is conceived of as being made up of units called photons having electro-magnetic waves of various lengths, each wave producing a different sensation of color when striking the retina of the eye; the combined effect being that of white light. When a ray of sunlight is passed through a quartz prism, it is broken up into the "visible colors of the spectrum"—violet, indigo, blue, green, yellow, orange, and red; arranged according to their wave lengths. Violet is the shortest, and red the longest. Among the invisible rays, both natural and artificial, are those shorter than the violet, such as ultra-violet and X-rays, and those longer than the red, such as infra-red and electric waves (wireless, radio, etc.).

The ultra-violet rays in sunlight are of the greatest interest to the sanitarian and hygienist. They affect many chemical compounds (the reason colored bottles are used for certain chemicals) and photographic plates; kill bacteria; energize food with the production of certain types of vitamins; form vitamin D from chemicals in the skin; cause sunburn and freckles; and act as a stimulant to growth and health in most forms of animal and vegetable life. In conditions of lowered metabolic and physiological processes such as rickets in children and in tuberculosis of the bones and joints, sunlight is usually quite beneficial. It may have harmful effects, however, such as severe sunburn, leading even to death in some cases; causes the horny layers of the skin to multiply (sailors' and farmers' skin) and may lead to skin cancers in certain individuals if exposed for long periods over a number of years (particularly true of those having little natural pigment in the skin such as blonde and red haired persons); causes conjunctivitis; may be the cause of certain types of cataract, of sunstroke, of snow-blindness and its equivalent by light reflected from snow, large bodies of water, or white sand.

There is very little ultra-violet light present in the sunlight striking the earth during the winter months. Smoke and dust in the atmosphere filter it out also, so that even in the summer very little will reach the ground of a smoky city.

The ultra-violet and other short invisible rays from the sun (called "vital rays" until more is known about them) will not pass through ordinary window glass or clothing. Hence while there may be plenty of what seems to be sunlight, the vital, stimulating rays do not reach one through ordinary window glass or through one's clothing. They will, however, pass through quartz glass which unfortunately is very expensive. The eyes may be protected from too much visible, infra-red and ultra-violet light by tinted glasses. For this purpose sage green and smoky glasses are usually preferred except in certain industries. There is still much to be learned concerning light and the effects of light and other rays so that this study is still in its infancy.

There are two general methods of *artificial lighting* or illumination: 1. Direct; and 2. Indirect.

In the direct method of lighting the light rays progress directly from their visible source. The disadvantages are glare, shadows and unequal diffusion of light.

In the indirect method of lighting the lights are concealed behind a screen. The light is thrown by a reflector against a light surface (usually the ceiling) which reflects and diffuses the light more evenly throughout the room, producing a soft, pleasing illumination without glare. This form of lighting is more expensive, however, and a combination of direct and indirect lighting is usually used although the totally indirect method is less tiring to the eyes.

In living spaces, wards and sick rooms there should be plenty of light where it is needed. The light should come from the back or sides, and be so located

as to prevent shadows or bright lights in the field of vision. The amount of light falling on a surface is usually measured in foot-candles, one foot-candle being the amount of light falling on a surface one foot away from a standard candle. Instruments for measuring the lights are called light meters, photometers, foot-candle meters, or photo-electric light meters, depending upon the principle by which they are operated. For ordinary reading 10 to 20 foot-candles should fall on the surface of the book or paper, depending upon the color of the paper and other factors. For very fine or exacting work such as watch making, reading verniers, operating, etc., from 100 to 200 foot-candles should be available.

The standard for natural light in buildings is one square foot of window space to 5 square feet of floor space. Roughly there should be one moderate-sized window for each bed in barracks and hospitals. There should be plenty of sunshine in the sick spaces, even if the patients have to wear tinted glasses to eliminate the effects of glare on the eyes. The most suitable colors for ceilings and upper walls are white or light buff, for lower walls the lighter combinations of green and yellow. Dark colors should not be used for this purpose.

Eyestrain, provided the vision is otherwise normal, results from overwork and consequent fatigue of the muscles of accommodation of the eye, which regulate the amount of light striking the retina. It is produced by excessive light and brilliant points of light in the field of vision, flickering or irregular light, and insufficient light, especially when reading, writing or performing work requiring continuous or exacting use of the eyes. Continued use of strained eyes may lead to permanent damage to the eye as well as reflex troubles, such as headaches, indigestion, lassitude, styes, etc. Preventive measures against eyestrain are indicated by the causes.

The **housing** of naval personnel constitutes one of the most serious problems with which military and naval sanitarians have to deal, because the nature of the "service" brings large numbers of men into close association, with a constant tendency, especially in war time, to "crowd" as many men as possible into barracks and on board ship. Overcrowding always is conducive to the spread of the diseases transmitted by the discharges of the mouth and nose and also is conducive to the dissemination of vermin. Under the close associations of barrack life, or life aboard ship, the types of bacteria found in the nose and throat tend to become uniform among the personnel, through the agency of the "droplet spray" issuing from the mouths and noses of persons when talking, laughing, coughing, and sneezing.

Thus the percentage of those who will become carriers of such pathogenic microörganisms as pneumococci, streptococci, meningococci, diphtheria bacilli, etc., if those bacteria are introduced, will be greater than among the same number of persons housed under ordinary conditions. The general principle, therefore, is that small barracks, preferably small individual buildings or units, are safer than large barracks. Large barracks should at least be divided into compartments to house the occupants more or less separately in groups as small as consistent with military and administrative requirements. *No barrack room should house more than 50 men.*

For housing in barracks the sanitary standards given in the Manual of the Medical Department, U. S. Navy, require that in all dormitories or sleeping rooms there shall be per man a minimum of 50 square feet of floor space, 450 cubic feet of room space, and 5 feet of distance between the heads of sleeping men. Hammock fastenings usually provide a 12-foot swing to avoid exceeding the first and second of those requirements and hammocks are placed 2½ to 3 feet on centers and alternate men are required to sleep with their heads in

opposite directions. Toilet and bathing facilities are based on 1 toilet for every 20 men; 1 foot of trough urinal for every 20 men, or 25 men to each individual urinal fixture; 1 lavatory, or 2 linear feet of trough lavatory or wash sink, for every 5 men; and 1 shower for every 25 men.

At stations or on ships having laundries, provisions should be made to launder as much of the men's clothing as conditions will permit. Special effort should be made to wash underwear, handkerchiefs, and socks as the process of thorough laundering will kill any pathogenic bacteria and fungi they might contain.

At first it might seem that with a large number of men living together in such a small space as the various decks of a ship afford, the dangers of overcrowding and density of population would produce their maximum effect.

The experience has been that the effects produced are not nearly so serious as occur ashore in recruit barracks under similar conditions. The chief reason for this is that the men aboard ship tend to divide into groups according to occupation or duties; they are "seasoned" men thoroughly accustomed to their environment, whereas ashore the reverse is usually the case (the admission rate among recruits being about three times greater than that for seasoned men); there is less opportunity for the introduction of new and virulent strains of pathogenic microörganisms; the mode of living is very regular and moderate; the men are under constant and close surveillance for the detection of sickness; and finally the sanitary and ventilation conditions are good. Possibly the greatest health handicap for men at sea is the frequent inability to procure fresh milk, fruits, and vegetables. (*See* "Mass immunity," p. 376.)

Navy regulations require that sports and exercises be encouraged. Special effort should be made to get the men whose duties confine them to the lower decks into the open air and sunshine. This benefits morale as well as increases the resistance to disease. Swimming is an important exercise and sport in naval life. Every one should be qualified in swimming. Drowning (much of which is preventable) is one of the leading causes of death from year to year in the Navy.

Careful regulations should be framed for the ship's barber shop and enforced to prevent the spread of any disease through insanitary barbering methods.

Soil and its relation to health and disease.

Were it not for the self-purifying power of the soil, the human race would have disappeared long ago. All water, except rain water caught and stored in cisterns, passes over or through the soil layer of the earth; therefore a brief consideration of the relation of soil to health and disease naturally precedes the study of water. Aside from this, certain pathogenic microörganisms remain alive for long periods in the soil by means of highly resistant spores and cause what are known as the "soil" diseases—tetanus, gas gangrene, botulism, anthrax, and malignant œdema. The most frequent and dangerous form of soil pollution, however, is that by the human intestinal and urinary wastes, causing typhoid and paratyphoid fever, bacillary and amœbic dysentery, hookworm disease and infestation by round worms.

Purification of the soil is largely effected by the "soil" bacteria or saprophytes, i.e., bacteria which live upon decaying organic matter. Saprophytic bacteria are found almost wholly in the superficial layers of the soil, often occur in millions to the cubic centimeter and are largely responsible for all decay. When dead organic matter reaches the soil it is attacked by these bacteria, and after passing through many chemical changes, is finally reduced to simple chemical compounds,

thereby making available for plants the carbon, nitrogen, and other compounds locked up in the dead bodies of animals and plants. The various species of these bacteria, both aërobic and anaërobic, develop mutually. The so-called "nitrogen cycle" which occurs in the soil is an illustrative example of this action. Saprophytic bacteria break down the dead nitrogeneous or protein matter into ammonia and carbon dioxide. The ammonia is further changed by "nitrifying saprophytes" into nitrites, then into nitrates, which dissolve in the soil water. In this way plants get their supply of nitrogen, without which they will not grow.

Microörganisms pathogenic to man require a food supply and the conditions found in the human body to reproduce. These conditions are not found in the soil, where also the millions of saprophytes accustomed to soil conditions act upon the pathogenic bacteria and rapidly kill them unless they can form spores or the soil is very highly polluted. Unfortunately the typhoid bacillus, one of the most dangerous pathogenic bacteria found in soil polluted by human excrement, withstands adverse influences, even freezing, for long periods.

In the tropics, where soil pollution with fæcal matter is common, and the soil is moist, together with a favorable temperature for bacterial growth, the constant presence of diseases transmitted by the intestinal discharges is readily explained.

The prevention of all such intestinal diseases rests solely in the sanitary disposal of fæces and urine.

Water and its relation to health and disease.

Water is a prime necessity of life, not only as an article of diet, but also for the proper cleanliness of person, clothing, and other objects used by man, and for other purposes.

While water is not strictly a food it forms an important part of the diet. A man can go without food a long time but he cannot live over 4 or 5 days without water.

The tissues are constantly being bathed in a fluid, and water forms the chief ingredient of all the fluids of the body. It distributes body heat and helps to regulate the temperature of the body by the physical process of absorption and evaporation. And it should be remembered that man must depend upon water for elimination.

Large quantities of water are required for flushing purposes in modern sewage systems, as well as for manufacturing. It not only "washes" the surface of the earth carrying with it pollution, but bodies of water, especially rivers, are utilized for the disposal of sewage. Hence there are the "water borne" diseases—typhoid and paratyphoid fever, cholera, and the dysenteries—from water polluted with human intestinal and urinary wastes.

On shore, provisions should be made to provide not less than 15 gallons of water per diem per person, and the Bureau of Yards and Docks figures on 125 gallons per day per man in designing water systems. The allowance of fresh water for all purposes aboard ship should never be less than 5 gallons per capita per diem. The members of a crew or the personnel of a command should be allowed sufficient water to meet the requirements of good personal hygiene.

The **sources of water supply** are conveniently considered as (*a*) rain water, (*b*) surface water, and (*c*) ground water. In addition, the Navy procures much of its water supply aboard ship by the process of distillation.

Rain water (snow or crystallized moisture), when collected and stored under sanitary conditions, is the purest of all natural waters. The rain should be

allowed to fall for a short period to wash the atmosphere and also the surfaces from which the water is collected. Cisterns should be of the same sanitary water-tight wall construction as wells and carefully protected against pollution. Cisterns and rain barrels, like all similar collections of water, should be screened to prevent mosquito breeding.

Surface water includes bodies of water which collect upon the surface of the earth, such as streams, lakes, ponds, and impounding reservoirs. Streams form natural sewers for the surrounding terrain, therefore surface water always must be purified before it is used for human consumption. Swimming should not be permitted in polluted water.

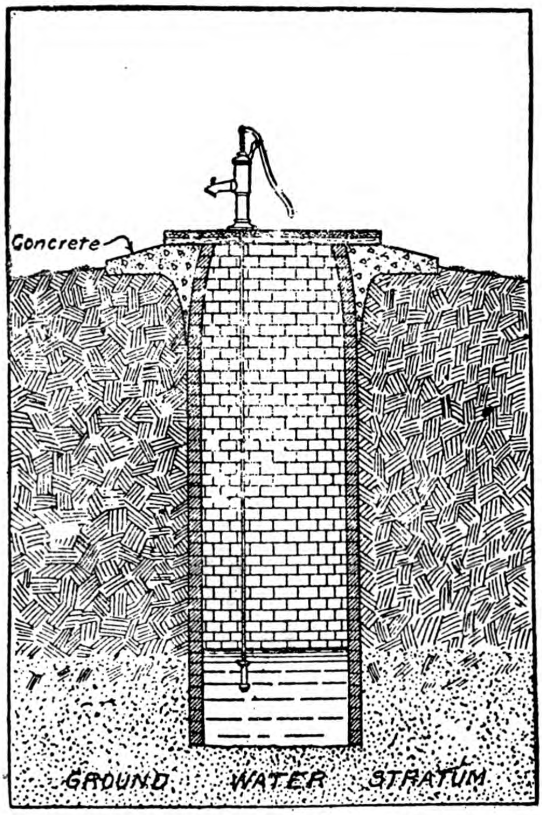

FIGURE 122.—A model well, cased with brick laid in cement mortar and properly graded, curbed, and protected. (Virginia Health Bulletin.)

Ground water is that which permeates into the "ground" and is obtained from springs, shallow wells, and artesian wells, according to the water-bearing strata from which obtained. These water-bearing strata lie above impervious strata of clay and flow toward large bodies of water, which explains why wells can be sunk and fresh water obtained next to bodies of salt water.

Springs are formed when ground water—that above the first impervious stratum—overflows upon the surface as a result of the geological formation. Spring water is safe provided it does not "spring" from limestone formation, and the drainage area around the spring is protected against contamination.

Shallow wells tap the first water-bearing stratum, and the water is usually of excellent quality and safe for drinking purposes, provided it is not from limestone formation and the well is properly constructed. The walls should be solid masonry and extend 12 to 18 inches above the surrounding ground level to prevent surface drainage into the well. (Fig. 122.) The top covering should be tight—pollution of shallow wells usually occurs through or around the top. Near the surface of the soil microörganisms tend to die and are filtered out together with other pollution as the water percolates down through the sand and gravel.

Artesian wells penetrate an impervious stratum of the earth's surface and provide a safe and satisfactory supply of water. (Fig. 123.)

Water obtained from limestone formation always should be regarded with suspicion, because the water may flow through the large cracks and crevices found therein, unacted upon by the purifying processes of the soil. Pollution may enter from privies, etc.

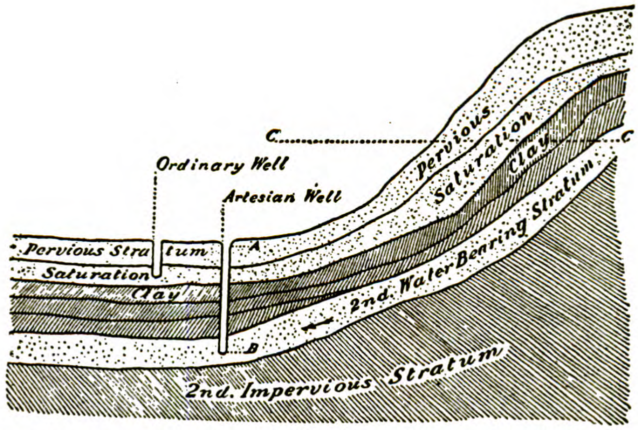

FIGURE 123.—Geological formation favorable to the obtaining of water by means of artesian wells. (Harrington.)

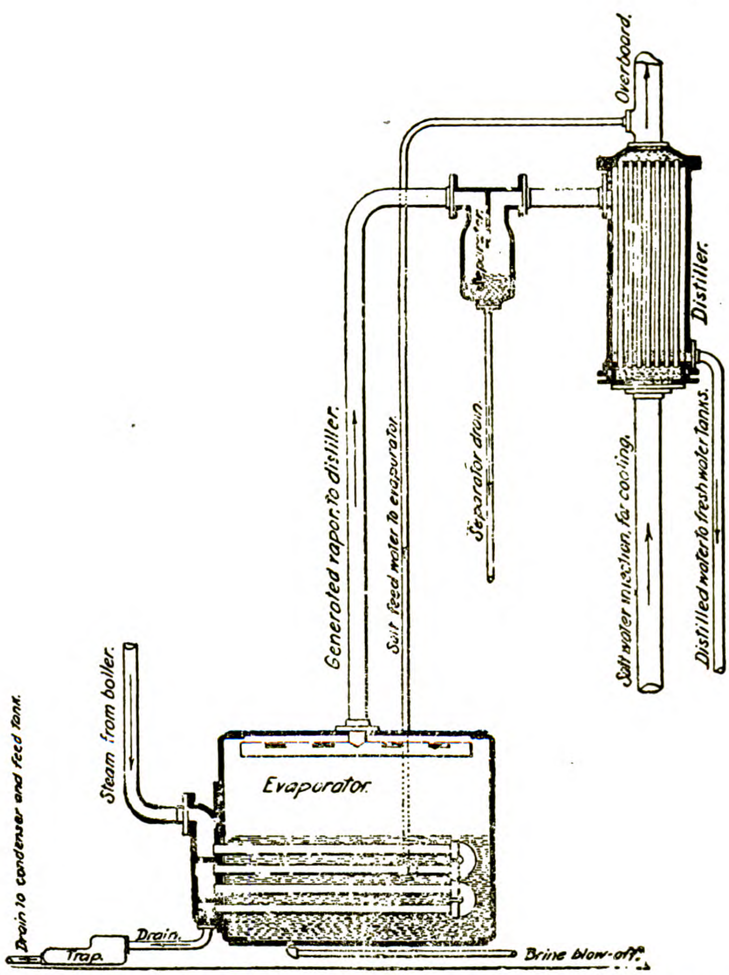

FIGURE 124.—A diagram showing the general plan of the apparatus used for distilling salt water on board ship. The salt water is evaporated by means of steam coils which pass through it. The vapor is then distilled, being cooled by passing around pipes in which salt water is circulating. (Gatewood.)

Ships, when away from sources of pure water, procure fresh water by the evaporation of salt water taken from over the side and condensing the resulting vapor, thus removing not only the salt, but all other impurities and bacteria. (Fig. 124.) Due to the vigorous boiling, the evaporators sometimes "prime," and droplets of salt water are carried over into the distilled water; also there may be leaks in the condenser coils, when impure salt water would contaminate the distilled water. For these reasons the distilled water is constantly tested for sodium chloride (salt), and if found in appreciable amounts the plant is stopped until the trouble is located and corrected.

Fresh water on board ship is stored in tanks which frequently need cleaning. The tanks should be entered if possible from manholes at the side to reduce the danger of contamination from without. Only men free from disease should be permitted to enter the tanks to scrub and clean them. They should wear clean rubber boots and clean clothing. After cleaning, a steam hose should be inserted and the tanks thoroughly steamed before freshly distilled water is run into them again.

Before any water supply is accepted for human consumption and frequently during its operation, a water supply should be subjected to a proper sanitary analysis, including:

1. A *physical examination* to determine odor, color, turbidity, taste, etc.

2. A *microscopic examination* to determine the number and character of the particles in suspension, especially algæ.

3. A *chemical examination* to determine the amount and nature of chemical impurities, principally free oxygen and the oxygen-consuming power; chlorides; ammonia (free or albuminoid); nitrites and nitrates. The latter (nitrates) are the terminal stages of the decomposition of nitrogenous matter brought about by the saprophytic bacteria.

4. A *bacteriological examination* to estimate the number and kind of bacteria present. The *bacillus coli* is the most important, because it is constantly present in the intestinal discharges of man and animals and, if found in water, it indicates pollution with intestinal wastes. When present it is logical to assume that the pathogenic microörganisms contained in the intestinal wastes of carriers or persons infected with cholera, typhoid and paratyphoid fevers, and the dysenteries might be present also. This is the most important single test to determine the purity of water.

5. A *sanitary survey of the watershed*, including methods of collecting, handling, storing, and distributing water, to discover possible sources of contamination, and the degree and kinds of pollution.

6. A *clinical survey* of the persons who have been drinking the water for cases of the diseases transmitted by the intestinal discharges.

While not of so much sanitary importance, the *hardness* of water is of great economic importance.

Hardness of water is due to the amount of chemical salts dissolved therein. Water, being practically a universal solvent, dissolves chemical salts as it passes through the soil. Hardness may be temporary or permanent.

Temporary hardness is due to the soluble bicarbonates of calcium and magnesium. Boiling removes these by driving off carbon dioxide and precipitating the insoluble carbonates of calcium and magnesium.

Permanent hardness is due to the permanently soluble chlorides and sulfates of calcium and magnesium.

When persons begin to drink hard water they usually suffer from varying degrees of diarrhœa. This is the chief virtue of the so-called "medical" and "mineral" waters. In regions where there are deposits of sulfur are found

sulfur springs and wells; in the vicinity of iron deposits chalybeate or iron springs and waters are found.

In regions where there is no iodine in the water, goiter is often present. In recent years it has become a practice in such regions to add small amounts of iodine to the water to prevent goiter. The iodine also may be supplied by using "iodized" salt, or by administering chocolate wafers containing iodine.

Water purification is practiced principally to remove all traces of contamination with intestinal discharges. By the purification of water and the sanitary disposal of intestinal and urinary wastes the pestilential outbreaks of cholera, typhoid fever, and dysentery can be and are being prevented.

The following are the principal methods used in water purification:

1. Clarification by sedimentation.
2. Filtration by (*a*) slow sand filters; (*b*) rapid, mechanical, gravity filters; and (*c*) pressure filters.
3. Sterilization with (*a*) chlorine; (*b*) ultra-violet rays; (*c*) ozone; and (*d*) copper sulfate.

Sedimentation is used to clear muddy or colored water. It may be natural by simply slowing the current or allowing the water to stand; or chemical, when coagulants, such as aluminum sulfate alone, or a combination of iron and lime, are added. These form a "floc" which settles to the bottom, leaving a clear water. Coagulants are used chiefly in connection with mechanical filters.

Slow sand filters are an imitation of Nature's purification process. Each filter is about an acre in size, either open or closed, and consists of tile drains (to carry off the filtered water) overlaid with a filter bed consisting of 1½ to 2 feet of coarse and fine gravel and 2 to 3½ feet of coarse and fine sand in concrete basins. The water to be filtered, usually about 3½ feet in depth, need not be previously treated by precipitants or coagulants, but may be subjected to plain sedimentation. A film of protozoa, saprophytic bacteria, and microscopic plants, which is analagous to the upper layers of soil, removes organic impurities in the water and kills pathogenic bacteria by biological action. These are filtered out as the water passes by gravity through the sand and gravel. This is a very efficient method and was preferred until the development of liquid chlorine as a sterilizant.

Rapid, mechanical, gravity sand filters are characterized by the use of chemicals to coagulate and precipitate suspended organic matter in the water and by sedimentation of the water to remove turbidity and the coagulated material before passing into the filters. The chemical coagulants or precipitants most commonly used are aluminum sulfate and iron and lime combined. Sedimentation may be accomplished by slowing the velocity of a stream or by allowing the water to stand in large surface ponds or in sedimentation or settling tanks. Purification of water by this method of filtration is being used more and more especially since apparatus for treating water with liquid chlorine has been developed, thereby insuring complete sterilization of water. The filtering material consists of about 12 inches of graded gravel upon which rests about 30 inches of graded sand. This type of filter clogs easily and requires frequent cleansing.

Pressure filters are closed tanks with a filter bed similar to the foregoing, the water passing through under pressure rather than by gravity. They are useful only for small supplies.

Sterilization may be applied to raw water after sedimentation or after filtration. It is a final and safe means of purification, provided of course it is properly done.

Chlorine is the most important of all disinfectants used for water purification. It is used as a gas compressed into a liquid and stored in steel cylinders for large water supplies; or as chlorinated lime for small water supplies, in the field, and for tanks on board ship. Chlorine, by its chemical reaction with water, liberates nascent oxygen upon which its bactericidal action largely depends. The process is, therefore, one of oxidation. Organic matter also has a great affinity for nascent oxygen and absorbs or fixes it before it can react with bacteria. Consequently the amount of chlorine required for a given water depends upon the quantity of organic matter contained. Ordinarily, liquid chlorine is used in from 0.1 to 0.5 parts per million for relatively pure waters. Chlorinated lime (30 per cent available chlorine) should be used in the proportion of 1 gram per 36 gallons of water. This will give about 1.5 parts available chlorine per million.

Ozone and ultra-violet rays can be used only in very clear and colorless waters. They are very expensive. Ultra-violet rays are frequently used for sterilizing the water used in swimming pools.

Copper sulfate is used chiefly to kill algæ.

Sewage and refuse.

The term **sewage** includes not only human excreta, but the other solid and liquid wastes from human habitations and factories usually discharged into sewers. It varies greatly according to time of day, season, and character of the community, but ordinarily contains about 99.9 per cent of water. The remaining constituents include objectionable substances such as floating solids, fats and oily products, settleable solids, putrescible matters, and bacteria.

By **refuse** is meant all other solid waste matter resulting from the natural activities of a community, such as garbage, ashes, rubbish, street cleanings, manure, etc.

Typhoid fever and paratyphoid fever, cholera, dysentery, and hookworm disease are spread by intestinal discharges and are frequently termed "sewage diseases." The disposal of sewage in such a manner that the bacteria and parasites which cause these and other such diseases are destroyed before they can reenter the body in any manner constitutes a real problem in preventive medicine.

Underlying all methods of sewage disposal are certain basic principles that have as their object the getting rid of sewage as speedily as possible, with the least nuisance to the fewest people, with the least danger to health and property, and at the lowest cost.

Sewage-disposal methods fall under two general systems: The *water-carriage system*, and the *dry system*.

The water-carriage system is based upon the principle of transferring the sewage from the immediate community to some other place where it can be disposed of in accordance with the existing conditions. A plentiful supply of water is required for flushing purposes. Final disposition is carried out in two general ways: 1. By discharging the sewage into bodies of water, the dilution method; or 2. By various treatment and purification processes.

Dilution is the oldest, simplest, and cheapest method of disposal of sewage and is suitable when, by dispersion in water, the impurities are disposed of without nuisance or menace to health. The process of purification depends upon certain chemical and biological changes for which a sufficient supply of free or "dissolved" oxygen in the water is essential. Under suitable conditions the complex organic matter is broken up and oxidized by saprophytic bacteria into simpler forms, such as nitrates, carbon dioxide, and water, as noted under the section on Soil. Bacteria are food for protozoa, the dissolved matter for algæ; protozoa and algæ are food for crustaceæ, and these in turn for aquatic

animals and fishes. Animal life requires oxygen and produces carbon dioxide, while plants consume the latter and produce oxygen. If the chemical balance (oxygen) is disturbed, the biological cycle just described is broken and a nuisance follows. There are many places where the dilution method is not always suitable unless the sewage is given some form of treatment, varying with local conditions as to degree and cost.

The determining factors as to the suitability of the dilution method are: (*a*) The amount and character of water in the receiving body, with reference to degree of sewage dilution and available dissolved oxygen; (*b*) The temperature of the water in the receiving body and of the atmosphere; (*c*) The current in the receiving body, with reference to diffusion and transfer and as to constancy of flow, whether constant in direction and force or tidal; (*d*) The proximity of sewer outlets to intakes for water supplies; and (*e*) The possibility of infecting waters at bathing beaches and other recreational areas, waters used by grazing cattle, or waters from which edible fish and shellfish are taken for human consumption. In other words, waters from which living pathogenic bacteria might directly or indirectly gain entrance to human bodies and cause disease are not suitable for use in the dilution method of sewage disposal.

The sewage of practically all ships and naval stations is disposed of in this manner.

Sewage treatment, by which it is purified, is necessary when sewage cannot be discharged into bodies of water without endangering the health of others.

The following procedures are employed separately or in combination in the treatment of sewage:

1. Separation and removal of suspended matter by:
   - *a*. Screens, coarse and fine, to remove matter such as wood, cans, etc.
   - *b*. Skimming tanks provide by flotation for the collection and removal of oil, grease, wood and other floating matter.
   - *c*. Grit chambers usually precede a treatment process for the separation and retention of sand, cinders, and other mineral matters.
   - *d*. Plain sedimentation where sewage is retained one to four hours to permit the process of clarification whereby solids are deposited by sedimentation unaided by chemicals.
   - *e*. Sedimentation with chemical precipitation.
   - *f*. Filtration and activation.
2. Destruction or liquefaction of organic solid matter in liquid sewage by anaërobic decomposition in:
   - *a*. Single-story septic tanks.
   - *b*. Two-story septic tanks of Imhoff or Emscher type.
3. Transformation of the organic matter to a condition of stability with oxidation processes such as:
   - *a*. Irrigation.
   - *b*. Sand filtration.
   - *c*. Contact beds.
   - *d*. Trickling filters.
   - *e*. Activated sludge.
4. Destruction of pathogenic bacteria by:
   - *a*. Disinfection with chlorine.
5. Disposal of sludge by:
   - *a*. Dilution.

Single-story septic tanks are ordinary flat-bottomed sedimentation tanks fitted with baffles to retard the flow and retain the sewage from 8 to 24 hours. The sludge remains for longer periods. They have a double function, one

relating to sewage clarification by sedimentation and the other to the decomposition of organic solids by anaërobic saprophytes.

Small septic tanks are frequently unsatisfactory because they give trouble from very foul odors from the released gases. Digestion also is often incomplete, due to the necessity for frequent removal of the sludge in order to insure adequate sedimentation space.

Two-story septic tanks consist of an upper sedimentation compartment and a lower compartment for storage and digestion of the sludge. The two compartments are separated by sloping walls having narrow slots at the bottom which permit settleable solids in the upper compartment to continuously pass into the lower. The gases generated in the sludge are diverted into gas vents and do not pass upward into the sedimentation compartment. Such tanks are called Emscher or Imhoff tanks.

Two-story tanks have proved to be more satisfactory than the single-story septic tanks. Under trained and intelligent operation many have produced thoroughly digested sludge without the occurrence of extensive odors.

Both types of septic tanks when first put in operation must be "seeded" with sludge from other tanks in use containing the anaërobic saprophytic bacteria.

If the effluent from septic tanks cannot be discharged into bodies of water without danger of contaminating water supplies, bathing beaches, or shellfish areas, it must be further purified. It has been seen that in the septic tanks the solid organic matters were broken down and some degree of purification was effected by the action of the anaërobic saprophytic bacteria. In the following process the purification is brought about mainly by aërobic bacteria, oxidation, and filtration. The chief purification methods are as follows:

Contact beds are constructed of crushed stone, cinders, etc., in series of two or three, the sewage flowing from one bed onto another. Purification is effected by physical oxidation with atmospheric oxygen, sunlight, biological action of aërobic bacteria, animal and vegetable life, and finally filtration.

Sprinkling filters are beds constructed of crushed stone, cinders, etc., and the sewage is applied to them by means of a fine spray from sprinkler nozzles, whereby the sewage is saturated with atmospheric oxygen. Otherwise the purification is substantially the same as occurs in contact beds.

Intermittent sand filtration beds are filled with coarse sand over a layer of gravel. The sewage, without any preliminary treatment other than being passed through screening and grit chambers, is flowed onto the beds. The purifying action is due to oxidation, both aërobic and anaërobic bacteria, animal and vegetable life, and filtration. The beds must be allowed to rest intermittently to permit the breaking down and oxidation of the material which otherwise would clog them.

The activated sludge process consists of aëration of sewage in tanks in contact with sludge from previously aërated sewage. The air is introduced from the bottom, produces greater oxidation, and also permits increased aërobic bacterial action.

In the *sterilization of sewage* liquid chlorine is used as in water purification. It is most effective when mixed with the effluent from the purification processes and is applied to insure the death of practically all the microörganisms.

In the dry system of sewage disposal fæcal and urinary matters are received in pails or water-tight receptacles, which are regularly replaced by empty sterilized containers. This system, also known as the bucket system, is suitable for isolated houses or small groups of houses and for temporary camps where the natural drainage is into the public water supply or where there is

insufficient water available for the water-carriage system. It is frequently used in military operations and has the advantage of immediate availability. The safety of the system depends upon proper care by the user and the collector—cleanliness in handling, prompt and frequent collection, disinfection of receptacles, protection of fæcal material from flies, and final incineration or burial in a suitable locality or discharge into sewers.

Aboard ships at sea the dry refuse, such as paper, boxes, etc., is burned in the fire boxes of the boilers on coal-burning ships or in incinerators on modern ships. Tin cans are punctured and thrown overboard. Wet garbage is discharged over the side through slop chutes.

In port, trash, garbage, and ashes have to be disposed of in lighters provided for those purposes. In navy yards, bins and containers are provided by the yard authorities and the refuse removed by them. Scrupulous cleanliness should be observed with garbage and trash containers to avoid unpleasant odors and attracting flies and rodents. Garbage cans always should be covered tightly.

Refuse ashore is generally estimated at one ton per person per year. It varies according to season and community. Methods of collection and disposal are as follows:

Collection Methods.	Disposal Methods.
1. Separate method, in which wet garbage is placed in one container, trash in another, and sometimes ashes in another.	Garbage is fed to hogs or subjected to reduction. In the latter case, the garbage is boiled in cookers, the fat skimmed off and sold for making soaps, candles, etc.; the tankage remaining in the cookers is dried and sold for making fertilizers. Ashes and noncombustible materials are used for filling.
2. Mixed collection, in which all wastes are placed in one container, the dry matters absorbing the excess liquid.	Incinerated or used for filling purposes.

Clothing.

The chief purposes of clothing are to maintain the temperature of the body, to hinder as little as possible the body's heat regulating mechanism by permitting evaporation from the skin, to afford free movement of the body, and to protect the body from injury by heat, cold, wind, rain, snow, etc.

Clothing is derived chiefly from the animal kingdom, which provides wool, leather, fur, and silk, and the vegetable kingdom which provides cotton, linen, rubber, paper, and other fibers.

The structure of the principal clothing fibers is as follows: Wool fiber is large and is made up of scales of hairs overlapping like shingles on a roof, which take up and hold moisture and large quantities of air. When spun into yarn from which cloth is woven it enmeshes greater quantities of air. Cotton fiber is flat and twisted spirally. Cotton thread is compact and contains practically no air. Silk fiber is a small, smooth tube. Linen fiber is cylindrical with cross lines indicating division of cells.

The value of material used for clothing depends upon its action in relation to the amount of air enmeshed in its fibers, its action in relation to moisture, and its special adaptability to varying needs and conditions. Air is a poor conductor of heat and if much of it is contained in the meshes of clothing it makes the clothing warm. Added layers of clothing give additional layers of air and thereby decrease heat loss. Water is a good conductor of heat and if clothing material takes up moisture rapidly and also permits its rapid evaporation heat is extracted from the body too quickly and chilling results.

The color of clothing has a bearing on its warmth, dark colors absorbing heat while light colors reflect away heat waves. Consequently white and light-colored garments are worn when the sun is hot, and dark-colored ones in cold weather.

Wool, being the natural covering of animals, and its structure as noted before, makes the warmest garments. It is woven in such a manner as to entangle great quantities of air, which being a poor conductor of heat, prevents sudden lowering or raising of the body temperature. It takes up moisture readily, but gives it off slowly; thus reducing the "cooling by evaporation." When saturated with moisture, its fibers still contain much air, which also checks rapid loss of heat. A good example of the effect of these qualities is the use of woolen garments by athletes and others who are exposed to cooling temperatures when wet with perspiration. Wool is very irritating to the skin, costly, wears poorly, and shrinks greatly.

Leather is used for hard wear and as a wind breaker.

Fur protects against the wind and cold because of the impermeability of the basic skin, and the large amount of air about the hairs.

Cotton fiber and thread contain very little air, and therefore do not make warm garments. However, it can be woven so as to entangle air, as in fleece-lined underwear, flannelette, etc., which are warm and soft. It gives off moisture rapidly and contains practically no air when saturated, hence wet cotton garments are chilling. Cotton is cheap, very durable, and is used generally for light, cool, summer garments and for making underwear.

Linen has much the same properties as cotton, but like silk is not used in the Navy. It makes excellent tropical clothing.

Paper at present has no wide adaptability for clothing purposes. It is used chiefly as a wind breaker. Its sanitary uses are increasing, however, as for towels, napkins, handkerchiefs, dishes, etc. It is cheap and when contaminated with human body discharges can readily be burned.

Rubber and rubberized garments are used to protect against wet conditions.

Garments can be treated with nonhygroscopic chemicals such as aluminum acetate, which causes them to shed water. This is called *cravenetting.*

From the foregoing it can be seen that in so far as materials and colors are concerned the *Navy uniform* is based on sound scientific principles. This is further enhanced by adapting the "uniform of the day" to the weather conditions as advised by the medical officer.

In the tropics, the head and back of the neck should be protected from the direct rays of the sun.

The relation of insects, vermin, and rodents to disease and methods for their extermination.

The primary considerations in the control of insects and pests and the prevention of the diseases transmitted by them are: To prevent them from breeding, to prevent them from coming in contact with infected cases, to remove all possible sources of food supply, and to use all possible control measures constantly.

Not only are **mosquitoes** bothersome pests, but they are responsible for the transmission of malaria, yellow fever, filariasis, and dengue fever. Patients with such diseases always should be thoroughly screened to prevent access of mosquitoes. Anopheles mosquitoes breed in semiwild conditions in swamps and bogs; the disease-transmitting Culex and Aëdes varieties breed about human habitations. Neither species flies ordinarily more than half a mile; therefore control measures against the disease-transmitting mosquitoes need not extend beyond that distance from the community or camp.

The development of mosquitoes may be conveniently studied in two general stages, the *aquatic* and the *aërial stages*, and control measures correlated therewith.

The eggs of mosquitoes are always deposited in water and hatch in 1 to 2 days into larvæ or wrigglers, which change into shrimplike bodies called pupæ in about 7 days. As mosquitoes require stagnant water for breeding, the most important of *control measures* is to get rid of the standing water by filling up depressions or draining off the water through subsoil or open drains. Drains should be as few as possible, clean cut, with sloping edges, narrow bottoms, and straight courses; lateral drains should connect at acute angles ("fishbone") to lessen deposits of silt. Frequent inspection and thorough upkeep of drains is necessary. If the water cannot be drained off, crude oil or kerosene or mixtures of these can be spread over the surface to suffocate the larvæ and pupæ which must have air to live. If the water is not to be used for humans or animals, larvicide (containing phenol) can be added to the water to kill the larvæ and pupæ; Paris green diluted with an inert dust also is spread over the water for this purpose. Water in cisterns, rain barrels, etc., should be screened to prevent access of mosquitoes to breed. Larvæ-eating fish can be added to ponds, cisterns, etc., where oiling, larvicides, or screening are not applicable. Vegetation which slows water and forms breeding sites for mosquitoes should be cleared from the banks of streams and ditches. Tin cans should be flattened or punctured and jugs and bottles broken, etc., in order to eliminate all standing water.

The aërial stage of development begins when the adult winged mosquito emerges from the pupa in 2 to 12 days, the entire metamorphosis from egg to adult requiring 9 to 12 days, according to weather conditions. Principal of *control measures* for adult mosquitoes is thorough and complete screening containing not less than 16 meshes to the square inch, preferably 20 meshes. Insecticides, such as sulfur-dioxide gas, burning pyrethrum or camphophenique, or one of the many insecticide sprays on the market are useful. Volatile or pungent liquids such as oil of citronella may be applied to the skin or clothing to repel them; the mosquitoes return, however, after the oil has evaporated. In malarial regions a valuable preventive measure is to destroy engorged Anopheles mosquitoes attempting to escape from sleeping quarters in the morning. Thick shrubbery harbors adult mosquitoes and should be cut or burned away.

Differentiation of mosquitoes and their morphological characteristics will be found under Parasitology in the section on Laboratory Procedures and Technique.

Flies may transmit many diseases under the following conditions: By having access to human body discharges (fæces, urine, sputum) containing infectious microörganisms (Fig. 125); by having access to contagious or infectious materials on the external surface of the body; and by biting and carrying infection from one person or animal to another, as in African sleeping sickness and tularæmia.

The common house fly or, as it is frequently and appropriately called, the "typhoid fly," passes through the following developmental stages: The egg hatches into the larva or "maggot" in 8 hours to 1 day; the larva changes into the pupa in 4 to 8 days; and 3 to 5 days later the adult fly emerges from the pupa. The entire metamorphosis requires 7 to 14 days or longer, according to weather and other conditions. Flies are prolific breeders, it having been estimated that a single female fly can produce 810 pounds of flies in a single season. (*See* p. 543.)

The presence of flies is an indication of nearby filth, as they breed in decaying garbage, animal manure, and human fæces. The feet of flies have adhesive pads enabling them to adhere to very smooth surfaces, and hairs and claws by means of which they hold on to rough surfaces. Filth and microörganisms are carried about on these pads and hairs. They also possess a retractile proboscis which transmits filth.

Control measures consist of preventing fly breeding by sanitary disposal of all body and other wastes, particularly manure; destruction of larvæ by kerosene, borax, incineration, etc.; and destruction of adult flies by poisons placed in sweetened water, fly paper, live steam, insecticides, and swatting, early in the season. No fly should be permitted to live in a sick room, a hospital ward, or a sick bay. Food and all body wastes should be thoroughly protected from them.

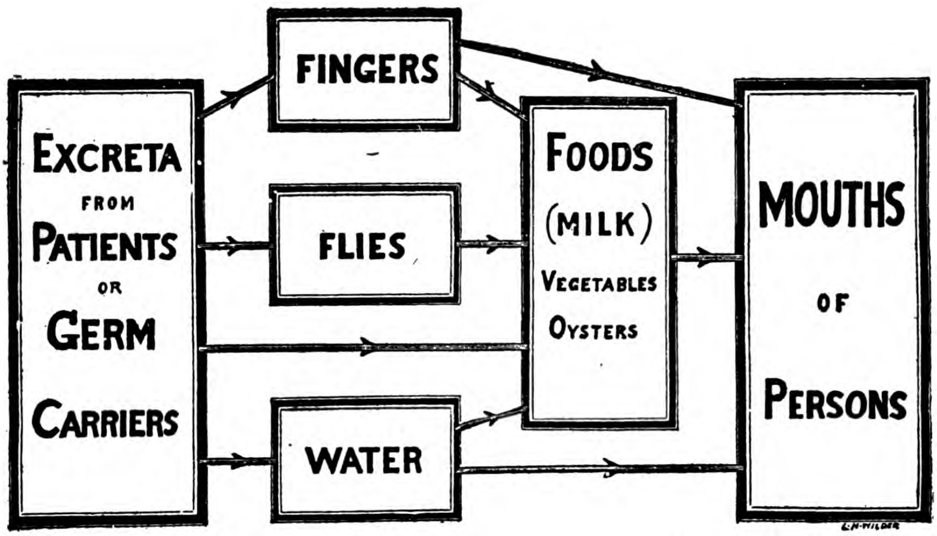

FIGURE 125.—Illustrating the participation of several routes of dissemination in the propagation of the typhoid bacillus. (U. S. Public Health Reports.)

Plague is a disease of rodents transmitted from one to another and from rodents to man by the bite of the flea. Rats also are considered the reservoir of trichinosis. They are particularly bothersome in trench warfare. Rats eat every known kind of food and are prolific breeders, and therefore easily exist and multiply everywhere. The estimated annual economic loss in the United States due to rats is 1 billion dollars. The Norway or brown rat, to which many names are applied, is the most common type. It is very ferocious and drives other types away from buildings.

Numerous *control measures* are used to prevent the spread of disease by rodents. They should be kept from human contact by rat proofing buildings, plugging up all rat holes with cement, and screening basements. Their food supply should be eliminated by protecting all food, garbage, fodder, etc. Traps of all kinds should be employed continually and baited with out-of-season foods, taking care to eliminate human odor from about the traps and to place them in rat runways, near rat holes, and out of sight. Shops and buildings should be fumigated with sulfur-dioxide, carboxide, or hydrocyanic-acid gas. Rat guards should be used on all ship's mooring lines. Poisons may be used but are not recommended in view of other available methods and the danger of poisoning other animals and persons, especially children. *To control rats it is necessary to use all possible methods all the time.*

While there are about 200 species of fleas, only 2 are of medical interest: *Pulex irritans* (the human flea) and *Xenopsylla cheopis* (the rat flea). As noted under rodents, the flea is responsible for the spread of plague, which transmission is purely mechanical. The eggs are laid in the cracks of floors or in loose earth. If deposited on the animal they drop off into its flea-infested bed. The eggs develop after 2 to 14 days into the larval form, which spin silken cocoons housing the larvæ, from which the adult fleas emerge in 10 to 14 days. The complete metamorphosis requires about 30 days, and if deprived of an opportunity to feed, adults die in 6 days or less. If the larvæ are killed, fleas will soon disappear. *Control measures* consist of fumigation with sulfur-dioxide gas or hydrocyanic-acid gas which destroys them, and crude fuel oil, kerosene, or gasoline sprinkled in the nests of animals, the cracks or crevices of floors or beneath houses is effective. Posts supporting houses can be smeared with crude fuel oil. In using inflammable oils special care must be taken to avoid fire. Use the same measures for infested clothing as are used for lice.

Lice transmit typhus fever, relapsing fever, and trench fever and their bites may lead directly or indirectly to secondary pathologic conditions of various kinds. There are five stages in the development of the louse requiring ordinarily about 16 days; the nit or egg, three molting larval stages, and the adult stage. They are insatiable feeders and live on human blood, needing at least one feeding a day. They cannot live over 10 days away from the body. There are three types of human lice: *Pediculus humanus* var. *corporis*, the clothing or body louse, *Pediculus humanus* var. *humanus*, the head louse, and *Phthirius pubis*, the crab louse. Lice are more common in winter than in summer because of the favorable temperature for the laying of their eggs and partly because the clothing is likely to remain unchanged and bathing is less frequent. The effect of temperature on the occurrence of lice is shown by the fact that lice are prevalent in certain places in high altitudes where the climate is cool, while in certain places which are low and hot there are very few vermin-infested individuals.

As lousiness results chiefly from overcrowding and insanitary conditions, the principal *control measures* and the best preventives of louse infestation are the maintenance of personal hygiene and of a sanitary environment. Clothing infested with *Pediculus humanus* var. *corporis* can be disinfested with live steam under pressure followed by a vacuum to dry the clothes, boiling for five minutes, or immersed in 5 per cent saponated solution of cresol for 30 minutes. Kerosene also is very effective. If males are infested with *Pediculus humanus* var. *humanus* the hair should be clipped short. In the case of females, the hair should be treated with a mixture of equal parts of vinegar and kerosene; and covered with a towel for one-half hour; then washed with warm water and soap. The kerosene kills the lice and vinegar loosens the nits. For infestation with *Phthirius pubis* the pubic hair should be closely clipped and mild mercurial ointment or camphophenique applied. Kerosene may be used but care must be taken to prevent burning or blistering the skin.

General delousing of troops or large numbers of people is carried out by having each person disrobe and their clothing bagged and turned over to attendants for steam disinfection. An inspection of the body is then made for nits, head, or crab lice. If found, the infested parts are clipped or shaved. A thorough warm shower is then taken, using liquid soap. Attendants in delousing plants should be protected from infestation by wearing vermin-proof suits.

The **bedbug**, *Cimex lectularius*, is a blood-sucking insect and seeks human skin at night in order to obtain nourishment. It has been suspected of being a transmitter of many different infections but there is no convincing evidence that it is. In biting preparatory to feeding it forces an irritating substance into the skin that may cause an urticarial, petechial, or macular eruption, and its bites, if numerous, are sometimes quite painful. The bedbug lives in cracks and crevices, particularly about beds, is most numerous where there are transients, as in boarding houses, hotels, etc., and is known to migrate from house to house. The eggs are deposited in cracks and in about 10 days hatch into larvæ, which pass through five moultings to adults in 2 or 3 months. *Control measures* in bedbug infestation require sterilization of bedding and mattresses, which is best done by steam under pressure. Ships or buildings badly infested can be fumigated with sulfur-dioxide gas or carboxide gas. For metal beds and springs the flame torch or live steam is effective. A pyrethrum spray is very efficient. A solution of 5 per cent cresol in kerosene may also be used. All liquid or powder insecticides must penetrate into the cracks where the bedbug hides and breeds to be effective. Bedding, ashore or afloat, should be aired and sunned at least twice weekly, at which time it should be examined carefully for vermin. Each piece should be shaken separately. Soothing lotions containing menthol, phenol, and camphor should be used on the skin to relieve pain.

Roaches are among the commonest and most offensive of insects which infest human habitations and are under suspicion of carrying several infections, including typhoid fever and "meat" poisoning. Cockroaches are nocturnal insects, hiding in cracks and crevices in the presence of light. They are voracious, eating everything or rendering it useless because of peculiar odor emitted. The eggs are laid in a hard capsule which almost fills the body of the female before it is laid. The eggs hatch and pass through several molts requiring at least a year under favorable conditions before full growth is reached. The most important *control measures* are scrupulous cleanliness about all places (galleys, bakeries, butcher shops, storerooms, etc.) where food is handled, and preventing their access to food. All unnecessary cracks and crevices where they breed and hide should be eliminated. Repeated fumigation with carboxide gas will destroy them. The usual insecticidal sprays are effective but must be sprayed into cracks repeatedly. A concentration of 15 per cent 20–1 pyrethrum concentrate with 5 per cent Lethane 384 in deodorized kerosene is an extremely efficient spray. Sodium fluoride powder sprinkled in their runways, about shelves, closets, drawers, etc., and allowed to remain helps to control them.

Disinfection and fumigation.

The distinction between disinfection and fumigation must be kept clearly in mind. Disinfection properly applied is of great value in the prevention of communicable diseases. With the destruction of infective discharges and the exercise of great care and cleanliness throughout the course of a communicable disease there is less need for terminal disinfection. The boiling of sheets, pajamas, towels and similar articles and a thorough scrubbing of the sufaces with hot water and soap, and disinfecting of bedding with steam is a more effective method of disinfection than by the use of one of the gaseous agents. Gaseous fumigation for the bacterial viruses has been discontinued as a sanitary measure. Gases, such as formaldehyde, are uncertain in practice and have the merest surface action but they cannot be depended on against tuberculosis or diphtheria. Fumigation has its place in preventive medicine and is used principally for the destruction of rodents in the control of plague, the extermination

of insects, especially bedbugs, and, in exceptional instances, for the extermination of mosquitoes as a disease prevention measure.

The agents used in disinfection are of two types, *physical* and *chemical.*

Physical agents of disinfection include sunlight, burning, boiling, and steam.

Sunlight is an active germicide, due to the ultra-violet rays contained therein.

Burning is of unquestioned efficiency and should be used whenever conditions permit. Incineration of wastes is practiced more extensively each year.

Boiling is very effective and of wide usefulness. The articles should be completely immersed for not less than 10 minutes in water actually boiling. The addition of 1 per cent of carbonate of soda renders the process applicable to polished steel and cutting instruments.

Steam is one of the most satisfactory disinfecting agents. It is reliable, quick and may be depended on to penetrate deeply. It may be used as flowing steam, or steam under pressure.

Flowing steam has the same disinfecting power as boiling water when the exposure is continued for 30 minutes. Steam under pressure is more powerful as a germicide than flowing steam. After the pressure has reached 15 pounds per square inch above atmospheric pressure, the temperature is approximately 120° C. (248° F.) and can be depended on to sterilize in 20 minutes. The air, being a poor conductor of heat, must be expelled from the apparatus at the beginning of the process.

The best method of applying steam under pressure is in a special apparatus with a vacuum attachment, the object of the vacuum apparatus being to expel the air and to promote the penetration of the steam.

Clothing, fabrics, textiles, curtains, hangings, etc., may be treated by either of the above methods as circumstances may demand.

Cooking and eating utensils, after washing, should always be disinfected by immersion in boiling water or steam. Where dishwashing machines are used the dishes are washed for 1 minute maintaining the temperature of the wash water at not less than 160°F, throughout the washing period and rinsed for 10 seconds with the rinse-water temperature maintained at not less than 180°F.

Commonly used **chemical agents of disinfection** are bichloride of mercury, phenol (carbolic acid), formalin, and chlorinated lime.

Bichloride of mercury is used very extensively, but as it attacks metals it cannot be used on them, and must be placed in containers of glass, china, wood, or earthenware. It coagulates albumin and therefore cannot be used to disinfect albuminous matters. It is incompatible with alkalies and their carbonates, lime water, soaps, and most metallic salts.

Bischloride of mercury is used commonly in a strength of 1:1,000, adding to the water used for solution 2 parts per 1,000 of sodium or ammonium chloride. Materials to be disinfected should be immersed in that solution for at least an hour. It is used for soiled fabrics and to wash down floors and walls.

Phenol (*carbolic acid*) is generally used in a 5 per cent solution. It is very efficient and is used to standardize disinfectants. Because of its expense many cheaper but effective derivatives are employed, chief among which is cresol, as in Liquor Cresolis Saponatus, U. S. P. (used in 1:20 solution). Phenol or its derivatives are used to disinfect fæces, urine, sputum, spit kits, contaminated clothing or fabrics, walls and decks of compartments. Exposure should be for 1 hour.

"*Formalin*" is a commercial solution containing not less than 37 per cent of formaldehyde gas and is used in a 5 per cent solution (commercial formalin 5 cc, water 95 cc). Exposure should be for 1 hour, and when used to disinfect liquids

or semisolids formalin should be added in sufficient amount to make a 5 per cent solution. It has a wide variety of uses and is also an excellent deodorant.

Chlorinated lime, containing not less than 30 per cent available chlorine, is used as a disinfectant by adding 1 pound to 4 gallons of water. This solution is satisfactory for mopping floors and walls. For disinfecting fæces, urine, and sputum, an equal amount of the solution should be added and allowed to stand for 1 hour.

The principal **gaseous agents of fumigation** used are hydrocyanic-acid gas, sulfur dioxide, carboxide gas, and formaldehyde.

Hydrocyanic-acid gas is extremely poisonous to all forms of animal life and is the most effective and the cheapest fumigant for the destruction of rats. It does not harm textiles, foodstuffs, metals or painted surfaces.

As small quantities of hydrocyanic-acid gas are rapidly fatal to man its use as an insecticide is necessarily limited. Its use requires the abandonment of the vessels for a more or less protracted time and is reasonably safe only when supervised by experienced personnel.

Fumigation by hydrocyanic-acid gas on naval vessels is authorized where in the opinion of the commanders of forces afloat, the conditions aboard ship are considered such as to make fumigation by this process necessary, and where rules of the U. S. Public Health Service require cyanide fumigation by that service before docking at a United States port.

It is not a practical method to be used by hospital corpsmen. For a more detailed discussion of cyanide fumigation refer to the Manual of the Medical Department, U. S. Navy.

Sulfur dioxide is a weak germicide but is exceedingly poisonous to mammalian and insect life. It has feeble penetrating power resulting in an action merely upon the surface. It bleaches fabrics and materials dyed with vegetable or aniline dyes. It destroys linen and cotton goods by rotting the fibers. It attacks almost all metals and therefore machinery and metal parts should be first coated with vaseline. As compared to hydrocyanic-acid gas, sulfur dioxide is much less dangerous to man but it cannot be depended on to kill more than 65 per cent of the rats in holds and buildings laden with cargo under which rats can hide.

To generate sulfur dioxide sulfur may be burned in shallow iron pots standing in pans of water, each pot containing not more than 30 pounds of sulfur. More equal distribution and better results can be obtained by distributing the sulfur in a number of small pots.

The following amounts of sulfur for each 1,000 cubic feet of space are necessary: To kill mosquitoes and flies, 2 pounds and exposure for 1 hour; to kill lice, 4 pounds and exposure for 6 hours; to destroy rats, mice and fleas, 3 pounds and exposure for 6 hours. The time of exposure should be doubled for cargo-laden holds and well-filled storerooms and compartments.

Carboxide gas is a very effective insecticidal fumigant of low toxicity to animals. Following exhaustive tests on board certain naval vessels it has been conclusively shown that it can be applied aboard ship by naval personnel without undue hazard, and with a minimum of interference of ship's routine or of movements of the vessels.

When required carboxide gas should be obtained by requisition on the nearest navy yard or station, but should not be carried on board vessels as part of the regular allowance.

Six pounds per 1,000 cubic feet is the required concentration for an exposure period of 3 hours for insects.

The following instructions on fumigation with carboxide gas should be adhered to:

1. Open wide all locker doors, furniture drawers, file cases, etc., and remove covers from mattresses and pillows.

2. Disconnect ventilating ducts at the point of entrance to compartment, wherever practicable, and apply watertight covers. Otherwise the dampers of all terminals must be closed and the louvers plugged with damp rags or waste.

3. Seal all openings which might permit gas to escape. Utilize masking tape or a combination of greased paper and masking tape for magazine vents, voice tubes, radio leads, enunciator chain leads, non-watertight doors, natural ventilators, etc. Close all drains in heads and bathrooms. Dog down all watertight doors and ports.

4. Maintain circulation of air by running all fans in space or spaces to be fumigated.

5. Open-flame heaters or exposed-element-electric heaters should not be used in areas being fumigated.

6. All cylinders should be securely lashed in the upright position and grounded before discharging gas to avoid static sparks. If cylinder is standing on linoleum or other insulating deck covering, grounding may be effected through wire lashing to a bulkhead or to metal furniture which in turn is grounded to some metal structure of the ship.

7. Make sure that all personnel in the area are accounted for. When all preparation is complete and all openings to the space closed except the exit, open wide the valves of the cylinders successively, beginning with the unit farthest from the point of exit and with the nozzle directed away from the operator.

8. The area of fumigation may be opened at the end of 3 hours. Personnel wearing oxygen-rescue-breathing apparatus should be detailed to open all airports and re-establish supply and exhaust ventilation. Two hours after full ventilation has been in progress it will ordinarily be safe for personnel to enter for their normal activities. Storerooms and other poorly-ventilated spaces should not be entered until the following day.

Experiments indicate that concentrations of carboxide lethal for bedbugs and cockroaches are also lethal for rodents in equivalent periods of exposure.

Formaldehyde gas can be depended on to accomplish surface disinfection but it is valueless as an insecticide. It apparently does not damage fabrics, metals or most colors. The use of this gas is decreasing in public-health work and is limited chiefly to disinfection of rooms, clothing and fabrics, where deep penetration is not required.

The most convenient and efficient method of producing formaldehyde gas is by pouring solution of formaldehyde on potassium permanganate or barium dioxide, allowing 500 cc of formaldehyde solution and 250 Gms. of potassium permanganate, or 250 Gms. of barium dioxide, for each 1,000 cubic feet of space. Place a glass or metal receptacle (10 times the size of the amount of formaldehyde to be poured into it to allow for foaming) containing the permanganate or barium dioxide in a large pan containing water. Then pour the proper amount of formaldehyde from a pitcher or other wide-mouthed receptacle on the permanganate or barium dioxide. Gas is generated in great amounts in a few seconds. Better distribution is secured by having a number of units, but care must be taken to "set off" those nearest the exit last. Exposure should be from 6 to 12 hours.

Maritime quarantine.

Medical officers of ships are required to comply with the quarantine laws of this and other countries. Persons exposed to any of the following diseases should be quarantined for the full period of incubation, viz., cholera, 5 days; yellow fever, 6 days; pneumonic plague, 7 days; typhus fever, 12 days; and smallpox, 14 days. Ships arriving in the United States with any of these diseases on board are quarantinable. Alien lepers are not permitted to land. Lepers, if citizens of the United States, must be handled in accordance with the local laws in force at the port of landing and are usually sent to the National Leprosarium at Carville, Louisiana.

Vessels arriving at any port in the United States from a foreign port are considered to be in quarantine until they are given free pratique. *Pratique* is a certificate, signed by the quarantine officer, to the effect that the vessel has, in all respects, complied with the quarantine laws, and all on board are free from quarantinable diseases, or the danger of conveying the same. Radio pratique is issued United States naval vessels when a medical officer is on board provided there are no contagious diseases aboard and the vessel has come from a clean port. Naval vessels coming from infected ports must stop at quarantine. One case of plague, cholera, or yellow fever makes a port an infected one.

United States *Bills of Health* are issued by the American consular officers at the ports of departure. They give a description of the vessel, the sanitary history of vessel, the sanitary conduct of vessel while at port, and the sanitary conditions existing in the port. A vessel coming from a foreign port to the United States should obtain a bill of health from the port official and also a United States consular bill of health in duplicate.

Each country has its own particular bill of health. The United States bill of health is the only one that is of service to the vessel upon arrival in a port in the United States although several may have been obtained at the port of departure. For instance a British ship clearing from the port of Rio de Janeiro, Brazil, for the United States is required to secure three bills of health, one from the British consul, another from the Brazilian authorities, which is a clearance paper, and the third from the American consul.

In case of a vessel sailing for the United States, the port of departure is the first port at which intention to sail to the United States is decided in making clearance from the port, or at which passengers or cargo destined to the United States are taken aboard. Not only must bills of health be secured from this port, but also from all intermediate ports of call until arrival at a United States port.

Naval vessels departing from a port in the continental United States for a port in the Canal Zone or United States possessions are not required to procure a bill of health or port sanitary statement at such port of departure except when plague, cholera, or yellow fever exists, or typhus fever or smallpox prevails in epidemic form in the port of departure.

A naval vessel departing from a port in the possessions or dependencies of the United States for a port in the Canal Zone or other United States possessions is required to procure a bill of health in duplicate at each port of departure.

A naval vessel departing from a port in the United States for a foreign port should procure a bill of health and have it visaed by the consular or other representative of the country or countries of port of call, if such ports can be determined upon prior to sailing. A naval vessel sailing from a for-

eign port to another foreign port should likewise procure and have visaed a bill of health.

Guantanamo Bay, Cuba, is construed to be a foreign port and bills of health are required for a naval vessel entering or departing therefrom.

Bills of health or port sanitary statements are issued in the United States ports by medical officers of the U. S. Public Health Service where available, otherwise by the collector of customs.

Personal hygiene.

By personal hygiene is meant any measure taken by the individual by which he can avoid disease, promote his health and strength, and enjoy their blessings. Such measures include the eating of the proper amount and kind of food, drinking the proper kind and amount of water, the wearing of proper clothing to suit the temperature, the breathing of wholesome air, all of which tend to heighten resistance; the avoidance of habits and practices which are liable to contract or transmit infectious diseases such as those borne by the mouth, nose, intestinal, and venereal discharges, etc.; the proper use of the eyes; etc. Cleanliness of the person and the clothing is one of the first requisites for good health. The entire body, if practicable, but at least the feet, armpits, and genitals should be bathed daily, and the exposed parts of the body, face, and neck as often as necessary. The hair should be kept cut short, and the finger and toe nails kept trimmed and clean. Dirty bodies and dirty infected clothing are very often the cause of skin and other diseases. A moderate amount of exercise in the open air should be taken regularly. With proper exercise the elimination of waste products from the body is increased through deeper breathing, and more perspiration; the muscles and heart become better nourished by more rapid metabolism, and a better circulation improves all the other functions of the body; the digestion is improved; and resistance to certain diseases is increased. The bowel should move daily, otherwise poisonous substances are absorbed into the system. If proper food is eaten and proper exercise taken, the bowel generally will look after itself. The mental state may affect the health and a cheerful state of mind promotes and benefits all the functions of the body and vice versa.

Not only is the practice of personal hygiene one of the greatest factors in the prevention of physiological diseases, but it is one of the chief aids to the sanitarian in destroying or preventing the transmission of the agents which cause the communicable diseases. Infective discharges from the respiratory tract can be readily transferred to others by promiscuous coughing, sneezing, and expectorating, or by the use in common of towels, drinking cups, and eating utensils. Good personal hygiene will prevent many of the air-borne and hand-to-mouth infections.

Following is a summary of the principles of personal hygiene which are adaptable to naval life.

1. Keep the body clean. Bathe the entire body, or as much of it as possible, daily.
2. Keep the hands clean. Always wash them before eating and after leaving the toilet. Keep the fingers away from the nose and mouth, and the finger nails clean and cut short.
3. Keep the feet clean and the toe nails cut short and straight across.
4. Change the underwear and socks frequently. Wear socks that are 1½ or 2 sizes larger than the shoe size and shoes that have been fitted carefully.
5. Brush the teeth every morning and evening or after each meal if possible. Have the teeth examined by a dentist at least every 6 months.

6. Eat slowly a moderate amount of nutritious food regularly and drink plenty of pure water.

7. Be regular in going to the toilet for bowel actions.

8. Take a moderate amount of exercise in the open air regularly. Breathe deeply at all times.

9. Sleep in a well-ventilated place with plenty of fresh air.

10. Avoid excesses of any kind, but especially alcoholic drinks and promiscuous sexual intercourse. If exposed to venereal infection immediately use prophylaxis.

11. Avoid persons with colds or coughs and keep away from others when suffering with one. Cough and sneeze in a handkerchief.

12. Avoid unnecessary exposure to extremes of weather. Change into dry clothes as soon as possible after getting wet, and dry the wet clothing before stowing it away. Clothing wet with perspiration should be dried and, if possible, washed before being stowed away.

13. Avoid using the toilet or other personal articles of others and do not allow others to use one's own.

14. Be cheerful.

The precautions regarding the care of the hands and fingers are of particular importance for the majority of infections are taken into the body through the mouth and the hands are responsible for a large number. Likewise the principle pertaining to "colds" should be closely observed. Finally, if there is one basic law, it is to avoid excesses of any kind.

VITAL STATISTICS

The importance of vital statistics to the practice of preventive medicine cannot be overstated. Without the statistical method comparatively little progress would have been made in epidemiology and less toward the prevention and control of disease.

Vital statistics may be defined as the branch of medical science that deals with the quantitative aspects of vital phenomena; in other words it is the bookkeeping of human beings. It comprises a numerical presentation of facts relating to sickness, deaths, births, and marriages for the population (or strength) as a whole, or for specified groups or classes. Vital statistics commonly are prepared specifically for the following groups or classes: Sex, age, race and color, occupation. They may be prepared for subgroups of these; for instance, whites of the male sex, belonging to the age group, 20 to 29. Furthermore, it may be that only males of a particular occupational class are under consideration.

Graphic methods for presenting statistics.

Although statistics present facts for study in the form of numerals, their significance cannot be grasped always until the statistical facts have been further presented in graphic form—curves, lines, bar charts, spot-pin maps, pin charts, etc. (Figs. 126, 127, 128.)

Graphic records are constantly necessary in statistical work for the following reasons:

1. They make it possible to perceive instantly facts which otherwise might be concealed or discovered only after careful study.

2. They make it possible to place before the eye at one time, in understandable form, information which otherwise could not be presented without long tables of figures accompanied by long and involved explanation.

3. They facilitate comparison of facts with other facts, closely correlated, remotely related, or, perhaps, as determined by study, bearing no relation whatever.

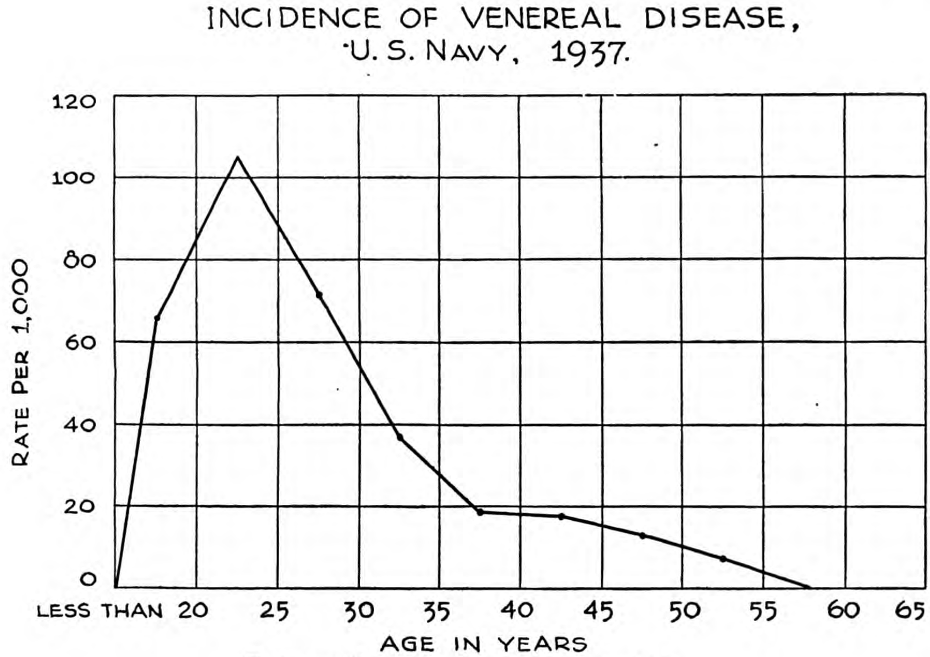

FIGURE 126.—Type of arithmetical chart.

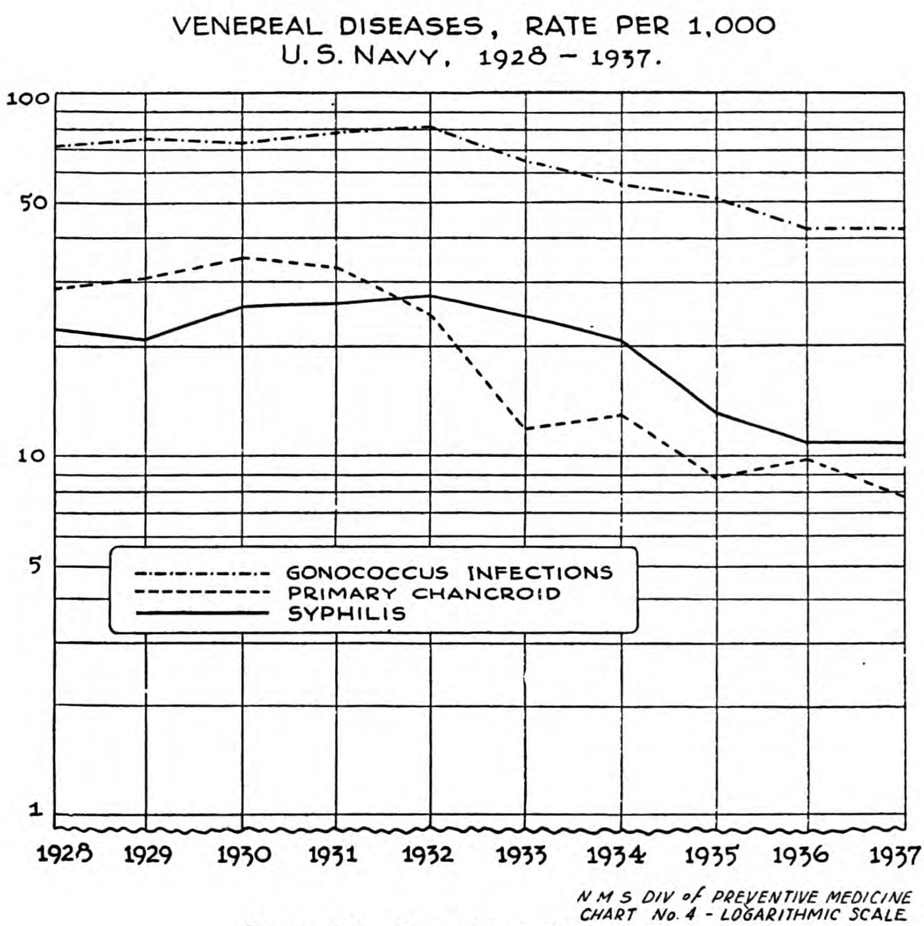

FIGURE 127.—Type of logarithmic chart.

4. By their means it is possible at times to make a person untrained in the statistical method perceive certain facts and appreciate their significance when by other means he could not be made to understand.

5. The relation or the possible relation of one set of facts to another set of facts, and still other facts may be recorded pictorially on a single chart or map.

6. In conjunction with the records for previous corresponding periods of time, graphic records show the trend of current events and sometimes enable one to look into the future for a short distance.

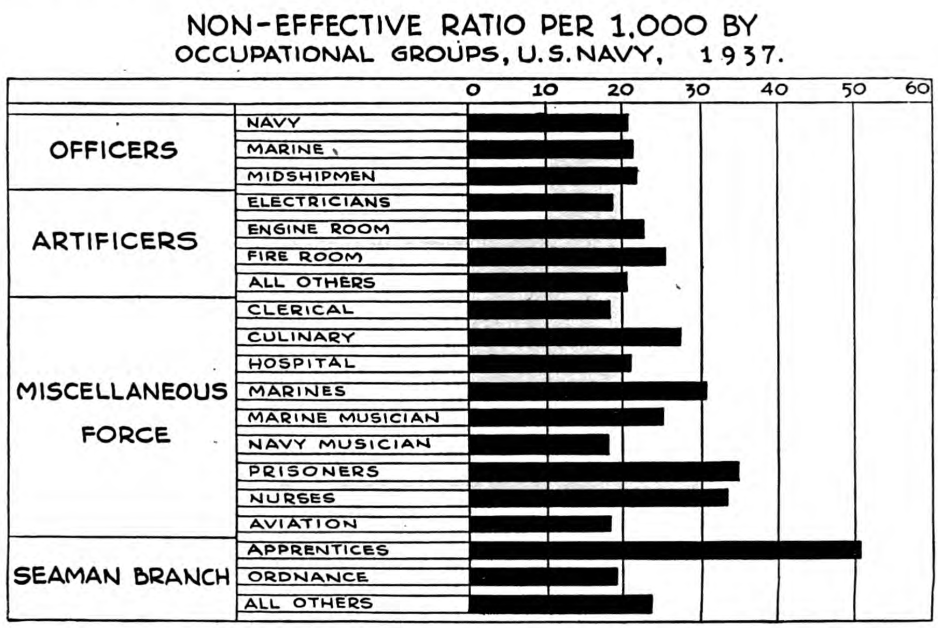

FIGURE 128.—Type of bar chart.

In administrative work the routine use of graphic records insures that important information which otherwise might be buried in the files and forgotten will be kept in view. Frequently such records can be used to advantage in attempting to convince other persons of the necessity for certain preventive measures.

Subject matter of the vital statistics of the Navy.

In the Navy vital statistics are limited almost exclusively to morbidity statistics and mortality statistics. In a few instances—Guam and Samoa—birth and marriage statistics are collected for the civilian population.

The subject matter of vital statistics of the Navy is composed of—

1. Basic data.—(*a*) Individual morbidity reports, i. e., the Form F Card, which shows the diagnosis and certain attending circumstances for each admission to the sick list; (b) Individual mortality reports, i. e., the Death Certificate, Form N.

2. Summarized written or telegraphic reports of new cases and deaths.

3. Compilations, i. e., tables or tabulations showing cases, deaths, or rates.

4. Graphic charts, spot maps, or charts posted by means of colored spot pins.

Correct vital statistics depend upon the accuracy and completeness of the basic data. Morbidity returns are incomplete when mild cases of a disease are not reported, and incorrect when erroneous diagnoses are recorded. A

morbidity report is incomplete when any of the data required on the form are omitted. Mortality reports are incomplete when any of the required data are omitted, and incorrect when sufficient collateral evidence to insure correct classification of the death with regard to cause is missing. The death certificate also must contain the necessary information to permit charging the death to the station or ship where the disease or injury resulting in death was acquired, and not to the place where death occurred—in a naval hospital perhaps.

Purpose of vital statistics.

The immediate and most important purpose, from the standpoint of preventive medicine, is to furnish information as to when, where, and under what circumstances, loss of manpower is occurring. It follows, therefore, that morbidity and mortality reports invariably should be made as promptly as possible. Reports should be forwarded promptly as a matter of routine even when, from the local viewpoint, no apparent reason for haste exists.

The historical value of vital statistics is also very great. Complete statistics must be prepared for each calendar year.

Use of vital statistics.

Alone, vital statistics do not necessarily prove anything. The facts thus presented in arithmetical form may or may not comprise all the facts pertaining to the question under consideration—almost invariably they do not. All epidemiological factors which possibly may have a bearing on the question must be taken into consideration.

It is because of positive but unwarranted assertions based on statistics, by persons who fail to observe proper limitations, owing to lack of thorough training in the statistical method, that uninformed or misinformed persons not infrequently question the value of the statistical method in general, and of any statistics in particular that may be invoked in perfectly logical support of a given contention.

The answer to the old saying, "There are two kinds of lies, ordinary lies and statistics," is, "Figures do not lie, but unfortunately liars do make use of figures."

The idea of comparison always is involved in statistics. The user may not be conscious of this, but everything in the universe is relative to something else, and if any given statistical statement appears to be absolute it is merely because it unconsciously is interpreted and weighed in association with similar information previously acquired. More frequently in practice the attempt frankly is made to compare the statistical information under consideration with other statistical data, and often with information of a different character as well.

Standards of comparison.

In order that any fact or set of statistical facts may be compared honestly with other facts in the realm of vital statistics they all must be expressed in the same ratio to population or group in the population.

The ratio itself does not matter; that is, the rate may be per 100, per 1,000, per 100,000, or per 1,000,000 of population as best suits the purpose. To change a rate per 100 to the equivalent rate per 1,000 is a simple matter of moving the decimal point over one place to the right. Rates per 1,000 are used for most purposes by the Bureau of Medicine and Surgery.

To make satisfactory comparisons it is necessary to have available standard rates, "norms," so called. The rate for a whole previous year, or preferably

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the mean rate for a series of previous years, is used for this purpose. Ordinarily figures should not be used for more than the five-year period immediately preceding. Conditions tend to change, and circumstances may not permit true comparison with figures relating to a more remote period. There are certain exceptions to this rule. For example, it may be desired to show a death rate, by years, for a long period of time.

In studying the rate from a given condition for a season of the year, a certain month for instance, the similar rates for the corresponding month of previous years should be available, although very likely it will be compared also with the average whole-year rate.

As a rule, morbidity and mortality rates are computed for current study by weeks, by months, and by years; occasionally by 5-year or 10-year periods. Exceptionally, as for an epidemic of influenza, morbidity and mortality rates are computed by days in order that a more complete statistical analysis of the outbreak may be made.

Rates for weeks or for months or other short periods of time fluctuate widely. The weekly rate is almost sure to vary a great deal from week to week. Because of this the fairest available whole-year rate always should be borne in mind.

Naturally it follows that the rate for the week or other short-time period must be expressed in terms of an annual rate in order to facilitate comparison. This is done as follows: The number of cases (or deaths) for the week is multiplied by 52 and the rate then computed. This rate is called the *annual rate for the week* and one merely assumes that if conditions were exactly the same for the other 51 weeks the whole-year rate would be that figure.

It is the practice to express all rates as annual rates, whether for a week, month, whole year, or longer period. In this way any rate may be compared directly with standard rates or with rates for any period of time, shorter or longer, corresponding or different.

Population statistics.

It is evident that there must be accurate or nearly accurate population (or strength) figures in order to compute approximately correct rates. In civil practice the estimated mid-year population as of July 1 is taken.

In the Navy the daily average strength for the period under consideration is used. This is determined by taking the total number of daily rations issued and commuted during the period (the figures being obtained from the Supply Department) dividing this figure by the number of days in the period and then adding the number of officers and others not entitled to rations.

The larger the average strength the smaller the error caused in a rate by incorrect figures. In any event the omission or addition of one case (or death) will have more effect on the rate than a considerable variation in the strength.

Annual rates.

The rate for an entire year is computed by multiplying the number of cases (or deaths) which have occurred during the year by 1,000 and dividing the result by the average strength for the year.

An annual rate per thousand for any definite period of time—a week, month, or quarter—may be obtained by multiplying the number of deaths or admissions for that period by 365 and dividing the result by the number of days in the period; the figure obtained by division then is multiplied by 1,000 and the result divided by the average strength for the period. If desired, the number of cases (or deaths) for a week may be multiplied by 52 instead of by 365.

Provisional rates and final rates.

Morbidity and mortality rates computed from week to week or from month to month must, of necessity, be provisional rates based upon reports for the period in question as received. Final rates ordinarily are not prepared until after the end of the year when final returns have been received. Then the figures may be reviewed and corrections made in weekly or monthly rates by excluding cases (or deaths) which actually did not occur in a given period, and by charging them to the week or month in which they did occur. (In civil practice, in revising death rates, corrections sometimes are made for deaths occurring in the community but chargeable elsewhere.)

Current morbidity and mortality rates are prepared as a matter of routine in order that the incidence, distribution, and severity of disease may be determined for comparison with similar figures for past periods and other communities.

It must be borne in mind that rates for short periods of time—weekly and monthly rates—fluctuate widely because of epidemic conditions, seasonal and other periodic or cyclic influences, and fortuitous circumstances. Such rates always should be compared with similar rates for corresponding periods of past years, although rates for past whole years furnish a guide as to what may be regarded as a normal average, seasonal and other influences, of course, being taken into consideration.

Comparison between one naval station and another, or between ships, and especially between ships and stations, should not be made without taking into consideration a number of conditions which may vary widely—number of personnel, density of population, overcrowding, housing conditions, permanency and character of the personnel, nature of activities carried on, environment, geographical location, climate, and season.

Rates other than those expressed in terms of annual rates.

Epidemic rate.—Epidemic morbidity and epidemic mortality rates are computed simply as the rate per thousand of strength attacked or died as a result of the epidemic, regardless of its length.

Attack rate.—Sometimes used to indicate the incidence of a disease among those presumed or known to have been exposed. Generally expressed as the percentage of cases occurring among contacts. With regard to influenza, it is permissible to conclude that practically everybody in the community has been exposed if the disease is epidemic.

Case fatality rate.—Percentage of fatal cases among persons attacked by a given disease. Computed by multiplying the number of deaths by 100 and dividing by the total number of cases, fatal cases included.

To express this, other terms, such as "mortality," "mortality rate," or "death rate," are frequently used. The objection to use of the expression "mortality" is that it is not always clear that the case-fatality rate is meant. The other terms have an entirely different meaning, viz., the ratio of deaths to the population or some group in the population.

Noneffective ratio.—This indicates the loss of time due to sickness. Along with deaths and invalidings from the service, the noneffective ratio is the final expression of the effect of sickness in terms of loss of manpower. It is the average number of noneffectives per given number of persons during the year, or other period of study. The noneffective ratio per 1,000 average strength would represent the average number out of each 1,000 constantly on the sick list during the period, or the number of sick days per 1,000 man days.

It is obtained as follows:

$$\frac{\text{Number of sick days during period}}{\text{Number of man days during period}} \times 1{,}000$$

For a period of a year this would be:

$$\frac{\text{Number of sick days per year}}{\text{Average strength} \times 365 \text{ (or 366)}} \times 1{,}000$$

For per cent of noneffectives multiply by 100 instead of 1,000; for noneffective ratio per 100,000 multiply by 100,000, etc.

Minimum rate.—The lowest rate in a series of rates.

Maximum rate.—The highest rate in a series of rates.

Median rate.—The rate which stands in a series halfway between the minimum and maximum rates.

The mode (*modal rate*).—The rate which occurs in the series with the greatest frequency. In some series the mode is not apparent.

The items of a series arranged in order from the minimum to the maximum figure are said to have been placed in *array.*

Mean rate.—The average rate independently computed from the combined basic data included in the series—not the average of the rates.

Example: Communicable diseases, Class VIII, at the Naval Training Station, Norfolk, Va., first quarter of 1937:

Month	Average strength	Cases	Annual rate per 1,000
January	3,089	412	1,570.40
February	2,899	234	1,052.21
March	3,122	120	467.64

The mean annual rate for the quarter is 1,022.90 (obtained as follows: 766 cases multiplied by 365 and divided by 90; this figure then is multiplied by 1,000 and divided by the average strength for the quarter, 3,037).

Average of the rates.—In the example given the average of the rates is 1,030.08 and the discrepancy between this figure and 1,022.90 is obvious. In rough calculations it is often sufficient to take the average of a series of rates, but the figure thus obtained must not be regarded as the mean rate. (*See* Weighted and unweighted averages.)

Combined rate.—The average rate for two or more communities combined—not the average of the rates.

Example: Death rate from disease, entire Navy, April 1937:

	Navy	Marine Corps	Entire Navy
Average strength	114,489	18,366	132,855
Deaths from disease	16	3	19
Annual death rate per 1,000	1.70	1.99	1.74

The combined rate is, therefore 1.74. Clearly, it would not be proper to take the average of the rates, 1.84, as the death rate of the entire Navy. If that were done, undue weight would be given to the comparatively small strength of the Marine Corps and not enough to the relatively large strength of the rest of the Navy. If the strengths were equal the combined rate and the average of the rates would agree. This also would hold for a series embracing more than two items if the strengths were all equal.

Other terms used in statistical work.

Series of data.—The items of a series may be either rates or basic statistical data (cases or deaths).

Geographical series.—The items in the series represent ships, stations, or other places.

Historical series.—The items in the series refer to time periods, each series representing a single place.

Weighted and unweighted averages.—If the arithmetical averages of two or more series are added together and divided by the number of series the average thus obtained is an unweighted average. It is an average of averages and does not give due weight to differences in strength; an average of the rates instead of a properly computed mean or combined rate as described in the preceding example.

Likewise, in dealing with cases or deaths directly, care must be exercised not to take an average of averages or the result will not be a properly weighted average; especially should comparison be avoided between unweighted averages for a series of places, or time periods, and a weighted average for another series.

Moving average.—This is calculated as a series of averages moving along, so to speak, through a series of rates. The moving average is most useful where the rates are to be plotted as a curve representing a great many time periods in unbroken sequence, especially when there is reason to believe that the fluctuations observed in the individual rates are largely due to periodic or cyclic influences. Suppose the death rate by years for a given place is plotted on a chart as a curve extending over a long period. There will be fluctuations from year to year, of course. If a curve for successive 5-year averages instead of by single years is plotted, the fluctuations will be smoothed out to a considerable extent, but the effect of unusually high or low rates will be merged in each separate 5-year average and the tendency will be to conceal any periodic effect on the rate that is due to cyclic phenomena which periodically recur, such as epidemics of influenza, measles, unusually bad winters, etc.

A curve can be plotted from *moving averages* that will smooth out fluctuating rates and yet preserve in the comparatively smooth curve the influence of regularly recurring fluctuations. This is best explained by an example. Suppose the following series of rates: 3.5, 4.2, 4.0, 6.1, 5.2, 4.2, 4.0, 3.2, 4.6, 4.2, and perhaps a longer series, be taken. To plot a moving average curve on a 3-year pivot (3-year moving average) proceed as follows: The average for the first three rates, 3.5, 4.2, 4.0, is taken and plotted under the 4.0 rate as the first moving average plot point. The next moving average point is obtained from the rates, 4.2, 4.0, 6.1; the next from 4.0, 6.1, 5.2, and so on, dropping a rate and taking up the next in the series for each new moving average point. The following diagram illustrates this, the figures in parentheses referring to the position on the chart of the first, second, third moving average plot point, etc.:

3. 5	4. 2	4. 0	6. 1	5. 2	4. 2	4. 0	3. 2	4. 6
		(1)						
			(2)					
				(3)				
					(4)			
						(5)		
							(6)	
								(7)

The moving average period may be taken as 5 year, 7 year, 10 year, or other pivot number. The closer the period chosen approximates the periodicity of recurring phenomena the better their influence will be brought out. It sometimes is desirable to try two or three moving average periods to see which works out best.

The question sometimes arises as to whether the first moving average plot point should be set back. For instance, in a long series of monthly rates the moving average is to be calculated on moving average periods of 12 months; strictly speaking, the first moving average plot point falls on the date of the twelfth month, but it is usually permissible to antedate it to the sixth month, in which case half of the data from which it is calculated lies before and half behind it.

Progressive average.—This is a simple matter of plotting under each new rate in the series the average of all preceding rates from the beginning of the series.

Suppose the death rate of the Navy by weeks from the first of the year is to be charted. The rates fluctuate from week to week. The progressive average curve shows, each week, the average annual rate from the first of the year to date. Inasmuch as all rates are expressed as annual rates, the progressive average for the last week of the year actually is the annual rate for the year, subject of course to revision upon receipt of final returns.

Of course, the correct procedure is to compute the mean rate for each new progressive average point, but for ordinary purposes the average of the preceding rates is sufficiently accurate to show the trend of the curve, which is frequently so obscured by fluctuations that it cannot be perceived without a progressive average curve, plotted along with the fluctuating curve. The following diagram shows the scheme, the figures in parentheses indicating the positions on the chart of the progressive average plot points.

3.5	4.2	4.0	6.1	5.2	4.2	4.0	3.2	4.6
	(1)							
		(2)						
			(3)					
				(4)				
					(5)			
						(6)		
							(7)	
								(8)

Compilation of statistical data.

On board ship, or at a naval station, compilation is ordinarily a simple matter of counting up the total number of admissions to the sick list, or the number of admissions on account of certain diseases, deaths, and number of sick days. The daily average strength must be determined in order that rates may be computed.

Where thousands of reports must be handled, as in the bureau, card-punching machines, sorting machines, adding machines, and machines for calculating rates are used.

Where a great many reports must be handled without machines, recourse to hand tally sheets must be had. The cross 5 method usually is employed; i. e., 𝍸 𝍸 𝍸 //.

Sheets of paper are ruled in accordance with the different combinations of data to be tallied from individual reports.

From the figures thus obtained rates may be computed, and these may be presented for study on graphic charts in the form of curves plotted to scale, or as bars plotted or drawn to scale.

Before statistical data can be compiled they must be definitely classified, both with regard to the average strength and the type of disease or injury. Average strength is classified in accordance with the established ranks and ratings of the Navy, and composite groups such as recruits, fireroom force, deck force, officers, enlisted men, age groups, force ashore, force afloat, etc.

To make accurate classification of diseases possible, medical officers are required strictly to follow the Diagnostic Nomenclature for the Medical Department of the United States Navy which has been compiled to meet the Navy's needs. The diagnostic titles in it are acceptable names of: (*a*) Diseases and conditions grouped in various anatomical, epidemiological, and miscellaneous classes; (*b*) Injuries; and (*c*) Poisonings. The epidemiological classification of the important communicable diseases is based upon the modes of their transmission which has a more or less direct bearing on measures for their prevention and control. Therefore when a medical officer is in doubt as to which diagnostic titles he should use reference should be made to the classification table in order that the title selected will place the case in its proper class. Care must be used to select the title which actually fits the case. For example, the title, "cerebrospinal fever, meningococcic" is to be used when, in the judgment of the medical officer, the disease is probably meningococcic meningitis, even though meningococci have not been recovered by lumbar puncture or by nasopharyngeal swab. The title "meningitis cerebrospinal" means some other form of acute cerebrospinal meningitis, as pneumococcic, streptococcic, etc., other than tuberculous meningitis or cerebrospinal syphilis.

Deaths are classified in the bureau in accordance with the International List of Causes of Death, as prepared by the International Commission of 1929 in Paris, France.

In order that the health of the Navy may be properly studied data concerning disabilities and deaths are compiled in the bureau to show the statistics of:

1. General morbidity and mortality.
2. Each of the more important communicable diseases separately: Cerobrospinal fever, meningococcic; chicken pox; diphtheria; encephalitis, lethargic; influenza; malaria; measles; German measles; mumps; pneumonia, lobar; pneumonia, primary broncho-; poliomyelitis, acute anterior; scarlet fever; tuberculosis (all forms); typhoid fever.
3. Communicable diseases exclusive of common infections of the respiratory tract and the venereal diseases.
4. Venereal diseases as a class and separately.
5. Diseases by anatomical systems.
6. Injuries and poisonings: Accidental; homicides and homicidal injuries; suicides and attempted suicides; war casualties; food poisonings; and drowning, all causes.
7. Diseases only.
8. Injuries only.
9. Poisonings only.
10. Primary disabilities, complications, and squelæa.

11. Occupational distribution of diseases, injuries, poisonings, deaths, suicides, homicides, and invalidings from the service.

12. Deaths, all causes.

13. Invalidings from the service, all causes.

14. Causative agents of accidental injuries and poisonings.

15. Character of accidental injuries and poisonings.

It must be remembered in statistical work that *two series of data which vary closely with a third may not bear a causal relation, or, indeed, any relation whatever to each other.*

Example involving secondary correlation.—In an epidemic of cerebrospinal fever, meningococcic, the epidemiological factors to be considered are:

Number, frequency, and distribution of the cases.

Number and distribution of carriers.

Length of service of those attacked.

Housing conditions.

Month of the year and weather conditions.

Personal hygiene of those attacked.

Fatigue, worry, and exposure to other predisposing influences.

Prevalence of other diseases.

It is only by establishing direct and indirect correlation between the incidence of the disease and these factors (and any other factors which seem to have a bearing) that the whole truth about the outbreak can be determined.

Experience during the World War showed that there was low correlation between cases and carriers but that a high degree of correlation existed between the incidence of the disease and certain combinations of the other factors which in turn were closely correlated with each other.

Methods of demonstrating correlation are: (*a*) By graphic charts, comparison of curves or bars and (*b*) by mathematical formulæ involving the use of coefficients.

Demonstration of cause or causal relationship.—1. The *synthetic method of proof*, by which known particular facts are pieced together in order to reach a more general conclusion. This is the inductive method of reasoning.

There must be agreement between the facts which are to be accumulated. It is, therefore, sometimes called the method of agreement. The following rules are applicable to the synthetic method of proof:

(*a*) Rule of agreement: If certain instances of the phenomenon in question have only one circumstance in common, that circumstance is the cause of the phenomenon (or the effect, depending upon the proposition).

(*b*) Rule of difference: When the phenomenon in question occurs in one instance and is absent in another, and one circumstance only is missing in the latter instance, all other circumstances being in agreement, then that one circumstance is the cause or an inseparable part of the cause of the phenomenon (or effect, depending upon the nature of the proposition).

(*c*) Rule of combined agreement and difference: When the phenomenon in question occurs in two or more instances and is absent in other instances, if there is one circumstance common to all instances in which the phenomenon does occur, and all instances in which the phenomenon is absent have nothing in common but the absence of that circumstance, then that circumstance is the cause or an inseparable part of the cause of the phenomenon (or effect, depending upon the nature of the proposition).

In the synthetic method a few instances are not sufficient to establish proof. The larger the series the stronger the proof.

2. *The analytic method of proof.*—Deductive reasoning by which a proposition is asserted to be true after which the proof is sought in correct premises,

and so on from one proposition to another until a known truth is reached and the main proposition proved. In other words, the mind looks ahead to the conclusion and then seeks to justify that conclusion by establishing correct premises for its logical proof. This method must be resorted to when it is not clear how to start the ordinary inductive method.

The figures for any special grouping of diseases can be obtained quickly in the bureau by means of sorting machines. The groups mentioned are used as a matter of routine, and rates also are computed for each of the 27 classes of the Navy nomenclature classification.

Following is a summary of rates used in presenting morbidity and mortality statistics:

Morbidity rates:

General morbidity rates (rates expressed in terms of the average strength without regard to sex, age, race, or occupational group).	For all causes. For a given disease. For a class of diseases.
Specific morbidity rates (rates for specified groups or classes in the average strength, as by age group, race, or occupational group).	For all causes. For a given disease. For a class of diseases.

Mortality rates:

General death rates (rates expressed in terms of the average strength without regard to sex, age, race, or occupational group).	For all causes (this is the *crude death rate*). For a given disease. For a class of diseases.
Specific death rates (rates for specified groups or classes in the average strength, as age group, race, or occupational group).	For all causes. For a given disease. For a class of diseases.

Interpretation of vital statistics.

It is the main purpose of vital statistics to establish relationship between different facts relating to sickness and death. Such relationship is termed **correlation.** The underlying purpose, of course, is to determine cause and effect. This brings one at once into the domain of logic.

Cause of an event.—The circumstances which *must* have preceded in order that the event should happen (Jevons; Lessons in Logic). An event seldom has a single cause. *Statistics do not in themselves establish cause.* However, the first step is to prove the existence of correlation, and this may be accomplished by the statistical method.

Correlation may be simple or complex.

Primary or simple correlation (*direct comparison*).—Two series of data only are compared. Example: Death rates from pneumonia set forth by months, to determine correlation between pneumonia mortality and season of the year.

From the statistical standpoint epidemiological data are known as variables. In any given problem one of the variables always is used to interpret or measure the other data and is termed the *independent variable.* In the example given the death rates are measured by months; months, therefore, constitute the independent variable.

Almost without exception, when time periods constitute one of the variables, it is the independent variable. The same is true of classifications such as sex, age groups, races, occupational groups, etc.

The data to be measured are termed *dependent variables.* Numbers of cases, deaths, morbidity and mortality rates, percentage of all sorts of things, bacterial counts, gallons, cubic feet of water, and similar data expressed in varying or fluctuating numbers naturally constitute dependent variables.

On a chart the horizontal scale always should be used to show the independent variable and the fluctuating dependent variable should be plotted to the vertical scale (the numerical scale).

When correlation is established definitely between *two* series of data a casual relationship is demonstrated thereby *provided connection between the variables also can be established.* Connection is not shown by statistics alone. *Causal relationship does not necessarily mean the only cause.*

Secondary or indirect correlation.—Three or more series of data are compared, as data not obtainable in suitable form for direct comparison. The processes of logic are more complicated in such instances, and the liability to arrive at an erroneous conclusion is greater.

3. *The indirect method of proof.*—Logical process of *reductio ad absurdum.*

Fallacies and pitfalls.—There is always danger of unfair comparison of morbidity and mortality statistics for different places when consideration is not given to—

1. Comparative reliability of the basic data.
2. The accuracy with which the data for each place were compiled and the methods of computing rates.
3. Epidemiological influences—comparative effect of potent factors.
4. The danger of concealed classification.

There is always danger that statistical data which purport to convey certain definite information may be concealing classes such as sex, age, race, color, or particular occupation, which, if revealed, might cause a very different interpretation to be placed on the figures. For example, if the incidence rates of pulmonary tuberculosis among employees in two different industries are compared a conclusion that one may be more conducive to the development of the disease than the other may be fallacious, because the figures may conceal the fact that the majority of employees in one are very young, while in the other they are mostly persons beyond middle age. In the same way nationality or race may be concealed. Negroes in the United States have a high death rate from tuberculosis irrespective of occupation.

The following example illustrates the necessity for constant guard against the introduction of concealed facts: A very extensive experiment to determine the possible prophylactic value of pneumococcus vaccine was conducted in a series of large institutions, by vaccinating every other newcomer, leaving each alternate one as a control. Now, some of these upon arrival were in good physical condition; others not. In cases of choice it practically worked out that an undue proportion of those who were not well to start with fell into the group of controls. For the first few months the death rate from pneumonia was much lower among those vaccinated. The figures concealed the fact that a higher proportion of those unvaccinated probably would have contracted and succumbed to pneumonia under any circumstances.

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Section 2.—ALLERGY

In the United States the word *allergy* is in general medical use as comprising all of the human conditions of specific sensitiveness and excluding the phenomena of experimental hypersensitiveness in the lower animal known as anaphylaxis.

An individual may be said to be hypersensitive when he reacts specifically, with characteristic symptoms, to a substance which in the normal individual of the same species produces little or no reaction.

For convenience the term anaphylaxis is commonly used in describing certain reactions occurring in the human, but, while it is not possible to assert that anaphylaxis does not occur in man, it is a fact that the existence of the condition of anaphylaxis in human individuals has not been demonstrated and use of this term is now restricted to conditions of sensitization in laboratory animals.

Experimental anaphylaxis may be produced in the guinea pig by injecting subcutaneously or intravenously minute amounts of horse serum or egg white and after an interval of at least 10 days the injection of the same quantity intravenously will produce symptoms of shock known as anaphylactic shock, and in some instances death may occur.

The term allergy, or hypersensitiveness in the human, includes the conditions known as allergic diseases and for convenience will be considered in the following categories:

1. Atopy or the Inherited Group.
    - A. Hay fever.
    - B. Asthma.
    - C. Food allergies or idiosyncrasies.
        - (*a*) Gastro-intestinal allergy.
        - (*b*) Urticaria.
        - (*c*) Angio-neurotic œdema.
        - (*d*) Eczema.
        - (*e*) Migraine.
2. Contact dermatitis.
3. Serum allergy.
4. Drug allergy.
5. Bacterial allergy or hypersensitiveness of infection.
6. Allergy due to parasites.
7. Physical allergy.

ATOPY

The clinical forms of human hypersensitiveness that are classified under the heading of atopy are so grouped because of their hereditary tendency. This tendency has long been known to play a part in the cause of pollen allergy, some families suffering more than others. Of 500 cases of hay fever, asthma, and food idiosyncrasies, investigators have been able to demonstrate conclusively the hereditary transmission of the tendency to become hypersensitive to various proteins. Research investigators have concluded that, when both parents are affected, 75 per cent of the offspring should be affected and that, when only one parent is affected, 50 per cent of the offspring should be affected.

The influence of heredity on the age of onset of symptoms of hay fever was shown in the fact that, in those cases in which there was a bilateral inheritance, 36 per cent showed symptoms before the fifth year and in cases where only one parent had a history 14 per cent developed symptoms before the fifth year and where no history could be elicited from either parent the incidence was only 5 per cent. These figures are maintained until the tenth year of life.

The conclusion must be drawn then that "inheritance" does exert a distinct effect upon the age of onset of hypersensitiveness, the more complete the inheritance the earlier the symptoms are manifested.

Hay fever.

Hay fever is a relatively common condition in the United States and the term originated among the laity from the belief that the symptoms were caused by something given off by hay. It is known under various names as June cold, summer cold, summer catarrh, pollen catarrh, rose fever, ragweed fever, pollinosis and several others.

The term hay fever is used to designate those nasal, pharyngeal, and eye symptoms which are the result in the greatest number of cases of specific hypersensitiveness to plant pollen and occur only in the human and bear a hereditary influence. It must be borne in mind that pollens not only produce mild or severe nasal, pharyngeal, ophthalmic and bronchial symptoms, but according to Rowe (*1*), may produce gastrointestinal symptoms, toxæmia, and migraine as well.

Air-borne pollens belonging to the class of inhalants are the important causative factors of hay fever. The pollen from ragweed is the greatest single cause of hay fever in the United States. Certain air-borne mold spores have been recently added to the inhalants causing hay fever and asthma among which the genus *Alternaria* is the most important. It is estimated that between 1 and 2 per cent of the total population suffers from hay fever.

Predisposing causes.—Among the predisposing causes of this disease heredity plays an important role. Coca (*2*) and Cooke (*3*) considered the hereditary feature in hay fever or asthma of sufficient importance to designate this type of hypersensitiveness by the word *atopy*, a word derived from the Greek, meaning "a strange disease."

Age.—Hay fever before the third year of age is rare, although symptoms may occur as early as the first year of life. It has been estimated that 25 per cent of all cases occur in the first decade of life, 35 per cent in the second, 25 per cent in the third and 10 per cent thereafter.

Race.—It is more prevalent in the white race, occurring less frequently in the black and yellow races.

Climate.—Any climate that favors pollination, such as the temperate climates, increases the prevalence of this disease. It has been stated that the air-borne pollens are the important causative factors although almost any pollen may be a cause when in sufficient concentration. In most instances the pollens that cause hay fever symptoms emanate from flowers that are inconspicuous as to fragrance and color while those that are conspicuous as to scent and color and whose pollens are heavy and sticky are insect-borne and not easily carried by the wind, are unimportant as a cause of hay fever or asthma. The pollens of golden rod, dandelion, sun flower, daisy, and rose are examples of insect-borne pollens.

There is considerable misunderstanding by the public as to the type of plants causing hay fever. Thommen (*4*) postulated five requirements for a pollen in order that it produce symptoms: 1. The pollen must contain an excitant of hay fever; 2. It must be wind-borne; 3. It must be produced in large quantities; 4. It must be sufficiently buoyant to be carried a considerable distance by the wind; and 5. It must be produced by a plant which is widely and abundantly distributed.

Trees, grasses, and weeds pollinate more or less at different seasons. The most prevalent type of hay fever in the United States is that caused by weeds

which pollinate in August, September, and October. This is known as the late summer or fall type of hay fever and the greatest offender amongst the weeds are the ragweeds.

The grasses rank next to the weeds and they pollinate in May, June, and July, the hay fever caused by them being known as the summer type. The pollinating season of the grasses is longer in the Southern States than in the northern. Timothy and June grass are the most important members amongst the grasses. Other grasses are red top, orchard grass, Johnson grass, and Bermuda grass.

Tree pollens are the least important of the three groups which cause hay fever. The hay fever caused by them is known as the spring type, the pollinating season usually being short, from April to June. Certain trees in the south are exceptional in pollinating during the summer and winter months. The spring type is caused by the pollens of the poplar, oak, ash, walnut, maple, hickory, birch, beech, and cedar.

Pollen concentration of the air is influenced by weather conditions. Rainfall during the night does not inhibit the crop whereas rain during the day hinders it. Sunshine during the early hours of the day causes the pollen to ripen in large amounts and be discharged. Land breezes are usually laden with pollen while sea breezes are usually free. The direction of the wind also plays some part in producing symptoms such as blowing over areas containing large amounts of pollen.

Within the past few years it has become apparent that not all patients suffering from seasonal symptoms of hay fever and asthma fall into any one or all of the pollen groups. According to Pratt (*5*), many persons suffering from hay fever from spring until long after frost are worse during the middle of the summer, between the grass and ragweed seasons. He states that many of these patients are sensitive to air-borne mold spores. Molds may behave like bacteria and produce infection of the lungs, body cavities, and the skin. Typical examples of infection of the skin are the epidermophytoses of the feet commonly known as Dhobie itch. Molds may also be noninfectious and act as sensitizers similar to pollen and other air-borne excitants or allergens. Skin tests with molds of the infectious variety produce delayed reactions similar to the tuberculin type of reaction, coming on in 24 hours or more. Noninfectious molds causing hay fever and asthma will produce an immediate reaction consisting of a hive and an area of erythema similar to the pollen reaction.

The molds that act as excitants in hay fever and asthma are, in order of their importance, the *Alternaria*, *Aspergillus*, *Hormodendrum*, and *Penicillium*.

The **symptoms** of hay fever start about the same time every year if the environment has not changed and the patient is not under treatment. The onset is gradual and mild, depending on the concentration of the pollen. Usually the early morning hours are the worst, decreasing during the day and increasing again at night. Local symptoms involve the nose, eyes, and pharynx, the nasal and eye symptoms being the most annoying. The nasal symptoms are sneezing, continuing sometimes until the patient is exhausted, and a profuse serous discharge from the nose which follows or accompanies the sneezing. The eye symptoms are itching, burning, lacrimation (flow of tears) and sensitiveness to light. The lids may be swollen and congested. Itching of the pharynx and a troublesome cough may cause considerable annoyance. Fever does not occur in uncomplicated cases of hay fever.

The **diagnosis** of hay fever is made by a positive history of atopy in the patient or members of his family; the seasonal occurrence; the eye and nasal

symptoms, and specific sensitivity tests with the suspected excitants as described under asthma.

All pollen therapy must be individualized. Specific treatment by means of pollen extract is well established. The results vary, perfect or almost perfect results are obtained in as high as 35 per cent of cases and satisfactory results are claimed in at least 80 per cent of cases. The purpose of specific treatment in hay fever or asthma which is due to an inhalant such as pollen or spores from molds is to increase the patient's tolerance to the excitant by administering it in gradually increasing doses.

In all known cases of hay fever the pre-seasonal method of treatment should be begun 4 to 10 weeks in advance of the expected attack or before the hay-fever season begins, the maximum dose being reached, if possible, before the onset of symptoms. Treatment with the maximum dose is then continued at weekly intervals throughout the hay-fever season. The injections of pollen extract usually number about 15, given at intervals from 2 to 7 days. The site of inoculation is usually the arm or the outer side of the thigh.

Pre-seasonal or *prophylactic treatment.*—The selection of the suspected pollen or other excitant is made from the skin test showing the largest reaction. Where sensitivity is marked, a study of local conditions and a knowledge of plant distribution is necessary to enable one to select the offending agent. Desensitization with the most irritating allergen or excitant will probably afford sufficient relief to the patient.

Usually it is not necessary to test the patient with every pollen which the patient may be sensitive to. Pollens of the closely related plants may have a common excitant, such as the active principle of timothy being present in red top, June grass, orchard grass and Bermuda grass. The entire family of the oats may be represented by a single oat. This also applies to the weeds.

Many pharmaceutical houses throughout the United States manufacturing the diagnostic pollen allergens for skin testing also furnish information as to the geographical distribution of the various plants. It is usually a good plan to use test and treatment sets made by the same manufacturer to obtain best results.

Co-seasonal treatment.—When patients apply for treatment during or just before an attack begins the same method of making a diagnosis by skin tests is necessary. The ophthalmic or eye test cannot be used after the attack has begun. Effective relief from hay-fever symptoms may be obtained by giving small, gradually increasing doses of the pollen extract at frequent intervals. The maximum dosage, which it is wise to give, should be reached at approximately the fifth injection and continued at approximately this level throughout the season.

Perennial treatment.—A common method now in use that offers the maximum degree and the greatest percentage of relief obtainable in hay fever is the perennial method of treatment. Patients treated by the pre-seasonal or prophylactic method may carry out their treatment until the season is over. Following this the maximum dose may be reduced to ¼ or ¾ and given semi-monthly throughout the year. As the next season approaches the dose is gradually increased again until the maximum dose is reached before the season starts.

Precautions for avoiding reactions.—A few persons may be unusually sensitive so that in the course of the treatment some doses may produce a severe constitutional reaction. In such cases the patient should receive at the next visit one-half the dose which caused the reaction.

Care should be taken so that no solution is injected into a vessel. After inserting the needle into the tissue pull back the piston of the syringe. In case blood enters the barrel the needle should be withdrawn and reinserted.

The patient should remain in the doctor's office for at least one-half hour for observation. In the case of severe symptoms such as sneezing, itching of the eyes or skin, or difficulty in respiration, 0.5 to 1 cc of epinephrine hydrochloride, 1–1,000, should be given and repeated if necessary. The interval between doses varies according to circumstances.

The next dose should not be given until any marked local reaction from the previous dose has practically disappeared.

A blood-pressure cuff or tourniquet may be placed above the site of injection in severe cases of reaction to lessen the rate of absorption and epinephrine solution injected into the other arm or above the constricting band. The band may be loosened after the reaction subsides.

Local treatment.—For immediate relief a nasal spray of an aqueous or oily solution of epinephrine 1–4,000 or 1–10,000 is helpful. These solutions may be used as eye drops for relief from the eye symptoms if necessary.

Medicinal treatment.—Ephedrine sulfate or chloride in doses of ⅜ to ¾ grain by mouth may aid in controlling the symptoms. Atropine sulfate in doses of 1/150 to 1/200 grain lessens the discharge but is of little value in relieving the symptoms.

Hay fever resorts.—The selection of districts known to be free from the offending agent offers relief for many. An ocean voyage is beneficial to those who are able to avail themselves of the opportunity. Air filters installed in the patient's bedroom or office afford relief just so long as the patient remains in the environment.

Asthma.

One of the common forms of allergy affecting the organs of respiration is asthma, commonly known as bronchial asthma, and may be defined as a condition in which the outstanding feature is wheezy breathing with a prolonged expiratory phase.

The **causes** of this condition are numerous. Bearing in mind the hereditary influence previously mentioned, the causes may be classified as extrinsic, those due to causes or conditions outside the body, and intrinsic, those due to causes or conditions inside the body. Under the *extrinsic causes* may be enumerated foreign substances inhaled or inspired such as pollens from ragweed and the grasses which are also the cause of many cases of hay fever, dander, and emanations from domestic animals or the feathers of birds, vegetable dusts such as flowers and face powders containing orris root, and other dusts such as house-dust or dust occurring in factories, as leather and wool dust, are offending agents.

The *intrinsic causes* are also very numerous. Among some of the important ones are foods. The ingestion of egg white is one of the most important. Cereal proteins, especially those of wheat, cow's milk, various kinds of fish and meats and a host of others are also offenders. Bacteria may cause asthma and an attack may follow a cold.

Other causes under the intrinsic group are reflex from the nose or throat produced by irritation of the nerves, and foci of infection such as the teeth or appendix. Nervousness associated with faulty hygiene or stress and strain may be a factor, the asthma completely disappearing when the source of anxiety is removed.

Climate influences the frequency of the attacks, and to some extent the severity, by its effect upon vegetation such as pollens.

Season has some effect upon the nature or quantity of existing agents, such as pollens, diet and clothing varying with seasons. High temperatures and humidity aggravate the disease while high altitudes have a beneficial action.

Age.—About one-third of all cases of bronchial asthma show symptoms during the first decade of life and about one-half start during the next three decades.

The **symptoms** of asthma are as follows: The onset is usually sudden but is more often preceded by symptoms of tightness in the chest, sneezing or a cough accompanied by wheezing.

Gradually or suddenly the illness may enter the paroxysmal stage. Attacks of dyspnœa or difficult breathing may recur frequently or at great intervals, the patient may be normal or the symptoms may be those that precede the paroxysm. The patient is frequently awakened from his sleep by an attack He assumes the sitting position, the inspirations are short, slow and deliberate, and the expirations long and wheezy and may be loud enough to be heard at a distance. The patient is pale or dusky, has an anxious expression and may perspire profusely, the so-called "cold sweat." The attack may last from minutes to several days. There may be only a slight cough at first but this later increases in frequency and is productive of a viscid or sticky type of sputum. The pulse is rapid and usually diminished in volume.

There is a characteristic position assumed during a severe paroxysm. The patient bends forward and grips objects tightly or he sits down with the elbows on the knees with the head down so that every accessory muscle of respiration can be brought into play.

The **diagnosis** is usually made with little difficulty and is facilitated by certain characteristic features in the patient's history, and the symptoms. The most common are as follows: A previous history or family history of allergic diseases classified under atopy; early age of onset; frequently recurring paroxysms of dyspnœa or difficult breathing with normal intervals between attacks; the tendency towards night attacks; examination of the sputum for Curschmann's spirals, Charcot-Leyden crystals and eosinophiles, and skin tests for hypersensitivity to important inhalants and foods. Skin testing reveals positive results in a large number of cases estimated to be approximately one-half to two-thirds of all cases of bronchial asthma.

In obscure cases it is advisable to change sleeping quarters or spend a short time in a dust-free room ventilated by filtered air. When positive skin tests are not obtained by food extracts, trial diets or elimination diets may be tried.

Tests for hypersensitiveness may be performed in several ways and have proved to be successful in the diagnosis of asthma, hay fever, and other allergic conditions. Cutaneous or skin tests are made as follows: (*a*) The scratch technique is the one commonly employed. Any surface of the body which is free from hair such as the flexor surface of the forearm or the back may be used. The area is cleansed with alcohol and allowed to dry, or followed with physiological salt solution, prior to making the scratch. A scratch approximately ⅛ inch in length in the skin is made with a sharp instrument, needle, or scalpel, being cautious not to cause bleeding. If the powdered extract is used a drop of tenth-normal sodium hydroxide is placed over the scratch and a small amount of powder is rubbed into it. If pastes instead of powder are used no alkali is necessary, the paste being rubbed into the scratch similar to the powder. A sterile tooth pick serves as an excellent

spatula for rubbing the extract into the scratch. After 20 to 30 minutes the solution or paste is wiped off and the reactions are read by comparing them with a control test made with the sodium hydroxide solution or a paste containing no extract. A large number of tests may be done at one time by this method (fig. 129). (*b*) The intracutaneous method is also known as the intradermal method and consists of the injection of a very small amount of the sterile extract into the superficial layers of the skin. Amounts

FIGURE 129.—Skin reactions to various extracts; scratch method. (Courtesy Dr. Albert H. Rowe.)

not to exceed 0.01 cc are injected using a small gauge needle, care being taken not to inject too many tests at one sitting. Absorption is more rapid than by scratch method and reactions such as an acute attack may be precipitated. The reactions are read from 15 to 20 minutes later comparing them with a control test made with the extracting fluid containing no extract.

In suspected cases of pollen sensitivity the conjunctival test may be used by dropping a small amount of the dry powdered extract in the eye. The lower lid is retracted and the powder dropped into the conjunctival sac. Redness with congestion, itching and lacrimation develops in a few minutes if the in-

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dividual reacts in a positive manner. The powder may be washed from the eye with a boric acid solution and a few drops of epinephrine solution 1–4,000 instilled if the reaction is severe.

In the reading of reactions the results of the tests are recorded as negative, doubtful, slightly positive, moderately positive, and strongly positive. A reaction is positive when there is a central wheal or light area of erythema or redness. The wheal may be absent or very small in some instances while in others it may reach an inch or more in diameter (fig. 130). As a rule the wheal is irregular in outline and may send out pseudopodia into the erythematous area. A test is said to be positive when it exceeds the control in size, either in the amount of erythema or the size of the wheal or both.

FIGURE 130.—Skin reaction to pollen extracts. Positive reaction easily distinguished by a typical hive, irregular in outline, surrounded by a zone of erythema.

Cases have been recorded as showing a delayed reaction, the cause of which is not understood, that may appear at the site several hours or days after the test.

The **treatment** of asthma consists of the prophylaxis or prevention of the disease and the treatment after symptoms have developed. Persons suffering from allergic diseases with an hereditary influence should be careful to select an occupation free from exciting factors such as dust, cereal flours, animal danders, and chemical irritants. Areas known to be free from pollens should be selected if possible, or every case of hay fever should be given specific treatment. The early recognition of allergic conditions so that precautionary methods may be instituted is a factor not to be overlooked.

Treatment of the paroxysm.—Epinephrine hydrochloride solution 1–1,000 is the drug of choice. It is administered subcutaneously in doses of 0.5 cc to 1 cc and repeated as often as necessary until the paroxysm is under control. It is not effective when given orally.

Epinephrine hydrochloride solution 1–100 is administered solely by inhalation and is an effective agent for prophylaxis and relief of allergic asthma. Relief usually occurs more rapidly than with the hypodermic injection. The spray is inhaled through the mouth with the aid of an all-glass atomizer which should deliver an even vapor-like spray, free from droplets. Ten drops of the solution are placed in the atomizer and the patient instructed to place the nozzle of the vaporizer just inside the mouth. Five or six inhalations, by squeezing the bulb once or twice, with 2-minute intervals, are usually sufficient.

Ephedrine in ⅜ to ¾ grain doses may be given orally and has practically the same action as epinephrine. It is slower in its action and is not so effective as epinephrine for controlling a severe attack. It is particularly beneficial in preventing a mild attack from becoming worse. It produces some unpleasant

symptoms in some cases such as headache, tremors, nausea, increased pulse, and insomnia. The symptoms are less noticeable or absent in epinephrine.

Morphine and atropine have been used but their use should be discouraged.

Iodides in the form of the potassium or sodium salts, acting as expectorants, may be given in doses of 5 to 10 grains several times daily.

Specific treatment.—The most simple yet effective method of specific treatment is prevention of contact with the exciting agents that cause asthmatic symptoms. When this procedure cannot be carried out satisfactorily then relief must be obtained by the methods given next.

Relief, and in many cases complete cessation of symptoms, occurs by raising the patient's tolerance to the exciting agent by its administration in gradually increasing doses.

Food hypersensitiveness can be overcome by avoiding the offending food in the diet. Milk as an exciting agent may be combated by the use of evaporated or powdered milks or by substitutes. Oral desensitization or as termed by some, hyposensitization, to important foods such as eggs, wheat, etc., may be attempted by the daily ingestion of small amounts and gradually increasing the amounts until the point of tolerance is obtained.

Inhalant sensitivity may be successfully dealt with by preventing contact with the exciting agents such as pollens and dust. Persons sensitive to dust may change their environment to a dust-free atmosphere. This can be accomplished by removing everything from the room except a bed which is made from substances harmless to the patient. If the contact cannot be avoided the desensitization method described under hay-fever may be resorted to. This is usually not necessary for exciting agents other than pollens, molds, and house dust. Inhalation of smoke of stramonium leaves, the chief constituent of most commercial asthma powders and of special cigarettes for the relief of asthma, often relieves the symptoms if the attack is not too severe. Nonspecific protein therapy such as the injection of peptone, milk, venom protein, and vegetable proteins has been tried. Vaccine prepared from the sputum or nasal secretions of asthmatics is a popular form of nonspecific protein therapy. The injection of one's own blood or serum, called auto-hæmotherapy and auto-serotherapy, has produced some favorable results.

Under the *physical agents for treatment* the Roentgen ray is more successful than diathermy, actinotherapy, or hydrotherapy. The artificial means of inducing fever by high-frequency current is one of the more recent methods of treatment. All these methods produce temporary results and are unreliable, being comparable in that respect to nonspecific protein therapy.

Surgical procedures for the relief of obstruction to the breathing passages such as removal of nasal polyps, straightening of septa, turbinectomy and tonsillectomy produce little benefit.

Endocrine substances such as thyroid, parathyroid, corpus luteum and ovarian extracts have proved effective to some extent.

Breathing exercises and change of climate have been resorted to. Patients suffering from chronic bronchitis and sinusitis will find a warm, dry climate beneficial.

Food allergy.

According to Rowe (*6*), food is the outstanding cause of ingestant allergy. Most physicians realize its frequency as a cause of mild to severe disturbances in most tissues of the body. Many people at some time in life, and especially in childhood, and as late as 50 or 60 years, may have mild or marked food allergy.

Foods which are eaten continuously in excess or at intervals are especially prone to produce allergy, such as milk, wheat, eggs, and various fruits.

The tendency to group reactions in some people to foods that are closely related biologically explains sensitization to all cereals such as wheat, rice, corn, barley, and oats. The same is true for citrus fruits, the cabbage group, or to all fish or shell fish.

Gastro-intestinal allergy.

Rowe states that gastro-intestinal allergy is probably the most common cause of alimentary symptoms. As with asthma, atopic eczemas, urticaria (hives), angio-neurotic œdema, or migraine, the predisposition to develop gastro-intestinal symptoms often exists as a familial tendency.

Coated tongue, canker sores, gastric distress, belching, burning, loss of appetite, pain simulating various diseases, and mucous colitis are some of the conditions due to food disturbances. There may be allergic symptoms referable to the liver, biliary system and appendix, due to food disturbances, as well as œdema and smooth-muscle spasm in the genitourinary tract.

The gastric tissues are often the site of food allergy. Allergy to foods affects the cells of the gastric glands and accounts for large amounts of mucous. Congestion of the mucosa and of the glands, with muscle spasm, can explain the stomach unrest and injured digestion which leads to belching, distension, sour stomach, nausea, vomiting, tenderness, and even poisoning.

In the small intestine there may be idiopathic hæmorrhages or bleeding and an excessive amount of mucous due to allergic origin. Localized allergy in different parts of the large bowel often produces sudden attacks of severe cramping pain or persistent soreness which is difficult to explain. The so-called unstable or irritable bowel is a frequent manifestation of allergy.

Pruritis ani or itching near the anal outlet frequently results from a localized eczema due to food allergy.

Urticaria (Hives, Nettlerash).

This condition may be defined as an acute or chronic skin disease characterized by the sudden appearance of smooth, slightly elevated patches, whitish, pinkish, or reddish in color known as wheals, and attended by severe itching. The urticarial wheal may be allergic or nonallergic in nature. The nonallergic wheal is due to the direct effect of irritant substances such as the toxins or stings and bites of insects and nettles. The allergic wheal is often due to idiosyncrasy to foods. This condition is frequently associated with angioneurotic œdema and when hereditary influence plays a part it may be transmitted through several generations.

Causes.—Certain food stuffs appear to be especially liable to cause hives, such as fish, particularly shell fish, eggs, pork, strawberries, and other fruits. Certain drugs mentioned under drug allergy may cause an acute urticaria.

Symptoms.—The lesions in urticaria vary greatly in size and shape, ranging from a pin head to a fingernail or larger. As a rule they appear suddenly, although they may be preceded by gastro-intestinal symptoms if due to ingested material. The individual wheals are whitish or pinkish in color, often with a reddish border, and cause intense stinging, burning, and itching. All parts of the body may be affected but the usual sites are the lower trunk and outer surface of the thighs and buttocks. They may appear suddenly and disappear in a few minutes or last hours and even days, leaving no trace.

Diagnosis.—In the acute cases the exciting cause may be determined by a history of ingesting food or drugs. In the allergic type a history of symptoms appearing after the ingestion of food should suggest food allergy. A previous

personal or family history of allergy in any form may be helpful in locating the cause and eliminating the exciting factor, bearing in mind that allergic manifestations may develop in patients without previous personal or family histories of hypersensitiveness. A history of anorexia or food disagreement is important.

Rowe (7) lists his trial diets next in importance as a diagnostic guide when food allergy is suspected. He states skin testing must take a position subordinate to history and trial diets in the diagnosis of food allergy. Routine testing of food allergies by the scratch method is important and positive reactions are helpful; however, it is generally recognized that skin tests are negative to 50 per cent or less of those foods which produce clinical allergies.

Treatment.—The treatment for the allergic type of urticaria may be divided into specific and nonspecific measures.

The specific treatment includes the avoidance of offending substances and the use of prophylactic injections to raise the tolerance of the patient to these materials. In the case of food allergy the diet is restricted. (*See* elimination diets at end of this section). Desensitization to foods is not attempted except perhaps in infants and children when they are sensitive to milk and eggs. In the case of serums and drugs causing acute urticaria, avoidance or substitution, if practicable, may be resorted to.

The immediate treatment, if due to something ingested which has not left the stomach, is to induce vomiting. A brisk saline purge is indicated as soon thereafter as possible. In a severe attack 1 cc of 1–1,000 solution of epinephrine hydrochloride, subcutaneously, repeated as often as necessary, may relieve the acute attack. Ephedrine sulfate ⅜ grain is also helpful.

The local application of calamine lotion containing 1 or 2 per cent phenol or menthol is beneficial to allay itching and a saturated solution of sodium bicarbonate, boric acid, or magnesium sulfate will also give relief.

Angioneurotic œdema (Quincke's disease, giant hives).

It has been suggested that urticaria and angioneurotic œdema are dependent on the same mechanism, urticaria involving the superficial layers of the skin and the latter involving the skin or mucous membrane and occasionally the viscera, and characterized by transient, circumscribed swellings. The lesions do not essentially differ from those of urticaria, the variation being in size only.

The swellings are usually preceded by itching, prickly or burning sensation, and vary in size from a few millimeters up to large areas, in some instances covering nearly the entire back. The swellings may be tense and elastic and nonpitting or soft and pitting. The skin may not change in color over the area or it may be pink or dusky red.

Areas commonly involved are the lips, the loose tissue about the eyes and mouth, the tongue, hands and feet, in fact any surface of the body may be affected. The swellings may persist for several days but usually disappear in 24 to 36 hours. The attacks may occur daily or there may be years between attacks. The diagnosis and treatment of urticaria applies equally to this condition.

Eczema (tetter, salt rheum).

The frequent association of allergic eczema with a personal or family history of asthma or hay fever points toward an hereditary abnormality of the skin. The transmission of eczema through four generations has been reported and it is considered that heredity can act as an important predisposing factor.

The excitants of atopic eczema are protein substances in foods which reach the affected parts through the blood after their ingestion. Eczema as an

expression of hypersensitivity to foreign proteins is most common in the infant, although persons of all ages may be afflicted. In general however, as life advances, the skin gradually develops an immunity to foods and becomes relatively more sensitive to contact reactions. Where eczema is of food origin, particularly in adults, it is usually accompanied by other manifestations of the allergic state.

Symptoms.—The disease is characterized by the presence of numerous types of lesions or manifestations such as erythematous, papular, vesicular, or pustular. Several of these may be combined, the most frequent being the papulo-vesicular. The vesicular variety is probably the most typical form of eruption. The majority of the vesicles rupture as a result of scratching or spontaneously and the patch becomes covered with thin yellowish crusts of dried serum and may ooze profusely, producing the so-called weeping type of eczema. Symptoms referable to the gastro-intestinal tract are similar to those of urticaria, namely, loss of appetite, and in the case of some children, gagging and regurgitation occurs when forced to eat food to which they are allergic.

Treatment.—The specific measures covering the allergic type of cutaneous conditions under urticaria may be applied to the allergic type of eczema in contrast to the nonallergic type of dermatitis. In recent years contact eczema from the oils of pollens and leaves has been recognized and its treatment with intramuscular injections of such sterile oils has been of some value. Prolonged pollen desensitization must be instituted when pollen is the cause of allergic eczema.

Food being the most common cause of allergic eczema, procedures similar to those under asthma and urticaria are necessary to eliminate the offending food. Asthma and eczema frequently occur together in the same patient or at different times.

The constitutional treatment is similar to that for asthma inasmuch as foods aggravate both conditions. Overeating should be prevented. Rowe's (*8*) trial diets contain foods which infrequently produce allergic manifestations and are successful in a high percentage of cases that are hypersensitive to certain foods. The general principle in the foundation of these diets has been to include one or two starches and meats, and two to four vegetables and fruits, together with sugar, oil and salt. A milk diet for several days prior to beginning the trial diets is beneficial provided that the individual is not sensitive to milk. Other foods may be added gradually.

For the acute conditions requiring additional treatment lotions containing soothing drugs, as well as preparations to allay itching as noted under urticaria, are beneficial.

Migraine.

Migraine may be defined as a condition characterized by periodic attacks of headache usually accompanied by nausea and often preceded by disturbances in vision.

Cause.—An hereditary influence can be shown to exist in many individuals who suffer from migraine. Certain kinds of food that have been known to cause an attack of migraine may cause asthma. In each the attacks are periodic and nervous influences may precipitate an attack of either. This similarity suggests an allergic state may exist in these individuals.

There is increasing evidence that a food allergy is the cause in a high percentage of cases.

Diagnosis.—The diagnosis is made on the personal and family history, skin tests for the offending allergen, and elimination diets.

Symptoms.—Preceding the attack eye symptoms may develop, later to be followed by intense pain across the forehead, between the eyes, in the occipital or temporal region and limited to one side. The pain is usually in the same place in every attack. Dizziness and nausea which may lead to vomiting is frequent.

The attack usually lasts from a few hours to several days and recurs at varying intervals. They are rarely accompanied by fever.

Treatment.—In the cases that have been proved to be due to hypersensitiveness in the patient, relief was obtained by allergic treatment where all other forms of treatment failed. Rowe reports many successful cases which received complete or nearly complete relief by elimination diets.

Stress and strain must be avoided as well as worry. Regularity of meals and regular sleeping hours are essential.

Foci of infection from tonsils, teeth, and sinuses must be removed.

Symptomatic treatment for the relief of pain consists of aspirin and similar products.

CONTACT DERMATITIS

The term contact dermatitis is now applied to a condition of specific sensitiveness which is limited to the epidermis and appears after surface contact with the exciting cause.

This category of allergic diseases was formerly known only through the skin disease known as dermatitis venenata, an acute inflammation of the skin caused by contact with various substances of a chemical, animal, or vegetable nature, and a term which still serves well as the type of a condition that is now increasing in number and importance. There is hardly an occupation which may not yield a special cause for contact allergy.

Some of the most important excitants causing this form of dermatitis are derived from the leaf, stalk, and root of various plants such as poison oak, poison ivy (*see* p. 560), poison sumac, primrose, daffodil, geranium, lily, satinwood, eucalyptus, and many others; chemicals such as formaldehyde, photogravure ink; trinitrotoluol or T. N. T.; paraphenylendiamine, a hair dye; other materials such as coal tar, furniture polish, soap, copra, oil of citronella, adhesive plaster, feathers and many others.

Symptoms.—The eruptions of contact dermatitis caused by plants are as a rule vesicular and accompanied by marked œdema or swelling, although purely erythematous eruptions or discrete blisters are observed. The onset is usually sudden, a few hours or days after exposure with involvement of the face, neck, wrists, hands, or ankles (fig. 132). There is a tendency for the dermatitis to spread by the fingers to other parts, especially the forearms or the genitals.

Diagnosis.—The diagnosis is made on the history of the case and by specific cutaneous tests using the patch test. This test may be applied in various ways depending upon the material to be tested. The test can be made with the natural material such as a leaf, powder, or fluid. An undiluted oily substance should be applied to a small area of the unbroken skin and the area covered for protection with a square of waxed paper and then with adhesive plaster. Alcoholic or other solutions may be applied to the skin by moistened blotting paper and covered with waxed paper and adhesive plaster.

The patient should be instructed to take off the patch as soon as itching is noticed and to remove the oil with alcohol or ether. A positive reaction appears in from 1 to 5 days as a more or less typical contact dermatitis varying from redness to vesiculation or blistering.

Treatment.—The ideal treatment is avoidance of the excitant; however, in many instances the excitant cannot be avoided without great inconvenience or expense. Contact dermatitis which develops in the home regions requires suspicion of cosmetics, soaps, foods, fabrics, furniture polish, waxes, cleaning materials, etc. If the history indicates an occupational source a change in occupation is desirable if practicable.

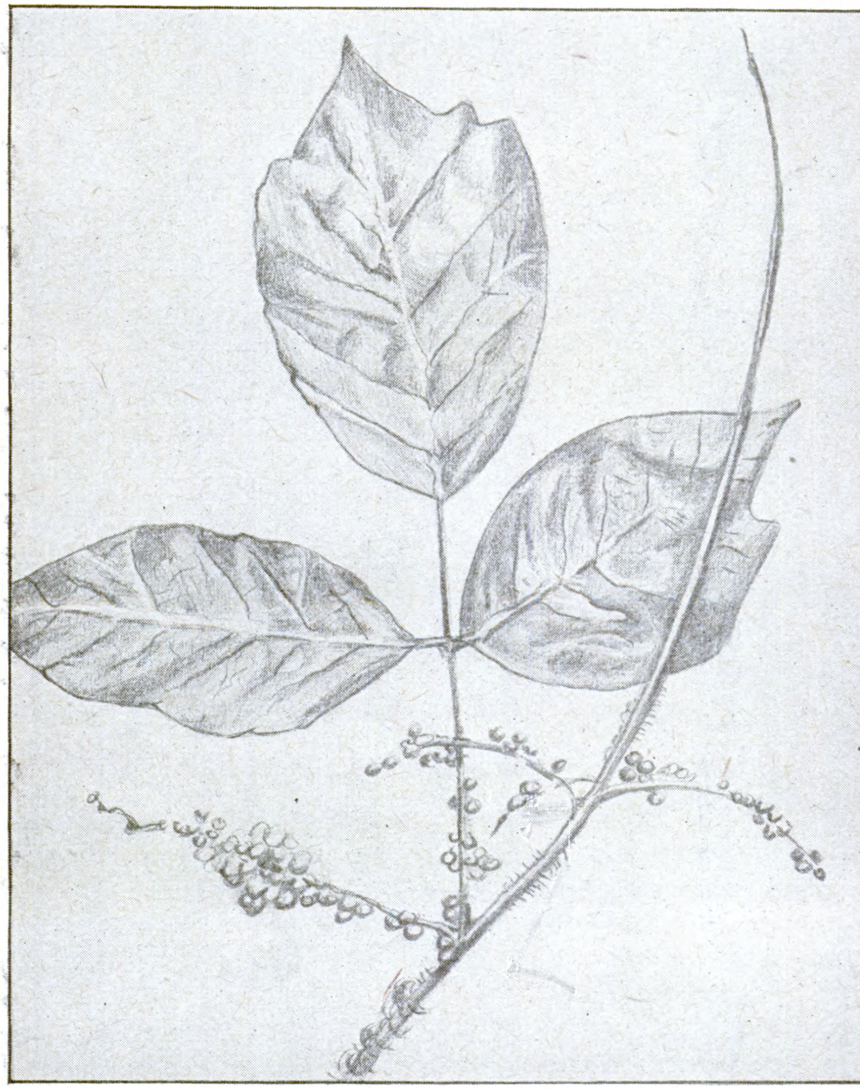

FIGURE 131.—Poison ivy branches showing the leaves, fruit, and aërial rootlets.

Contact dermatitis caused from the oils of pollens and leaves is treated by intramuscular injections of a solution of the respective oils. Three or four injections have been beneficial in many cases.

If the dermatitis is seasonal begin the injections about 3 weeks previous to the expected symptoms, following directions as recommended by the manufacturer furnishing the treatment material. Testing material as well as the treatment may be purchased from pharmaceutical houses handling biological supplies.

Local treatment.—Upon exposure the poison is on the surface of the skin and may be removed by thorough washing and rinsing, using ordinary laundry soap. In the early stages the disease may be controlled by scrubbing the parts with benzine followed by rinsing with alcohol. After the disease has been present for several days these measures are useless and astringents should be used, i. e., calamine lotion, liquor aluminum acetate 1–20 in water, 5 per cent aqueous

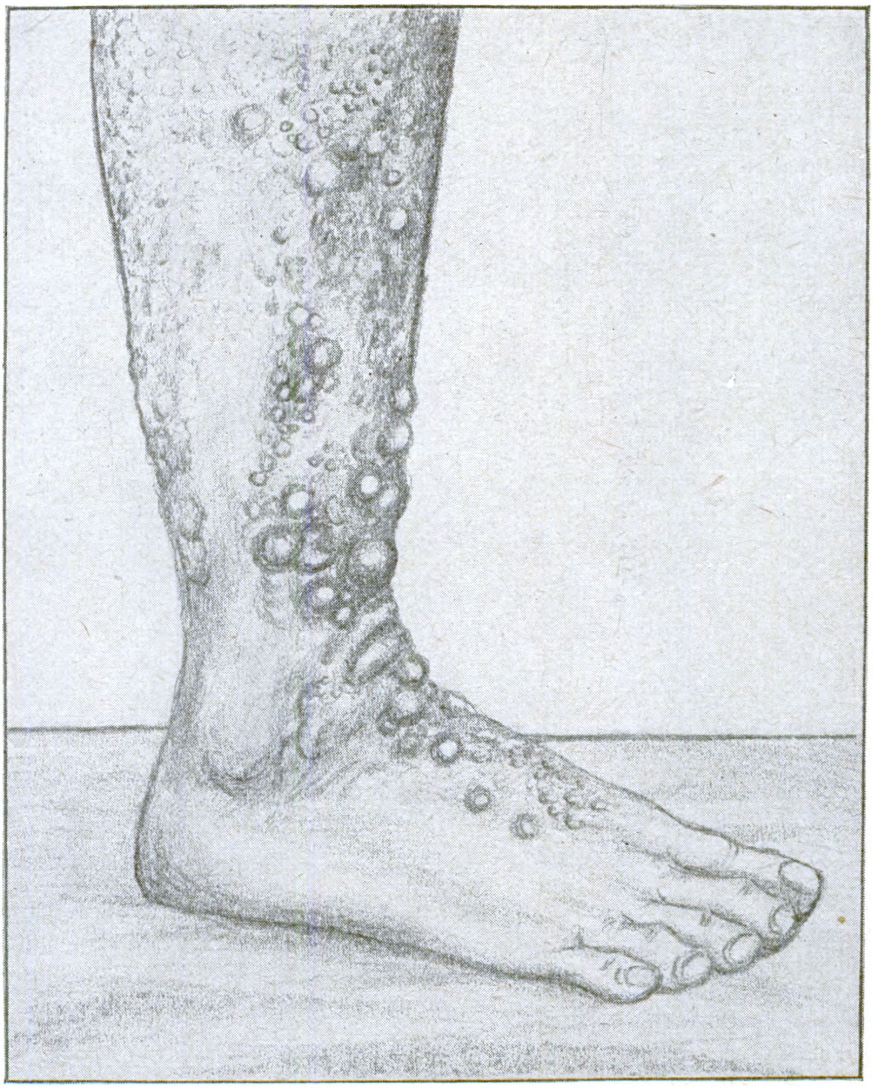

FIGURE 132.—Dermatitis venenata (poison ivy).

solution of ferric chloride, 5 per cent solution of potassium permanganate, or fluidextract of grindelia diluted with 5 to 10 parts of water. During the exudative stages ointments or oily preparations should not be used as they tend to dissolve and spread the poison.

SERUM ALLERGY (SERUM DISEASE)

Serum disease (or serum sickness) is an allergic reaction resulting from the administration either into the soft tissues, the blood stream, or spinal canal of

preparations containing a foreign serum. The reaction may be mild or severe.

The frequency with which serum disease or sickness occurs makes it imperative, if possible, to ascertain whether there is a previous history of having had asthma, hay fever, or any of the allergic diseases. It is also important to know whether serum has been given at any time during life following an injury or in the process of immunization for the prevention of disease. The well-known antitoxins used in the prevention and treatment of tetanus, diphtheria, scarlet fever, and many others are typical examples of those that are frequently administered and in which serum sickness is often seen. (*See* p. 375.)

Symptoms.—When serum is administered to an individual for the first time there is usually a period of 6 to 12 days before the onset of serum disease. In some cases where large amounts of serum have been administered the disease comes on as early as 3 hours after administration and the severity of the symptoms depends upon the susceptibility of the individual. In rare cases illness does not appear for 2 or 3 weeks.

Some individuals may show nothing more than a few hives and some swelling of the superficial glands following the administration of large amounts of serum and lasting for only a few days, while others after receiving a few cubic centimeters will show a large number of hives, fever, œdema, painful joints, and swollen and tender glands for several weeks.

The common symptom is fever, occurring in about one-third of the cases, the degree of which is often considerable, reading as high as 106° F., although an elevation of only 1° may occur. Associated with fever in a large number of cases is an eruption. The eruption may be urticarial (hives), macular (spotted), papular (pimple), vesicular (blister), hæmorrhagic, or in the form of erythema (redness). The serum eruption may be local, occurring only about the site of injection, or general, involving all parts of the skin.

The fever and eruption may occur together although not necessarily so. The highest point of the fever is usually accompanied by the appearance of the rash or on the day previous to it. Relapses occur occasionally after being free from 4 to 14 days.

Individuals who have had a previous injection of serum in any form, upon receiving a subsequent injection may develop alarming symptoms or even fatal reactions. Persons susceptible to asthma and certain allergic nasal conditions are particularly susceptible. These reactions are termed serum accidents and usually occur immediately. In some cases almost before the needle is withdrawn local itching and swelling occur. If the attack is severe, sneezing, tickling of the throat, choking sensation, cough, or swelling of the face, hands or the whole body may occur. An acute attack of asthma may develop and may be followed by convulsions and death.

Those who suffer from asthma due to coming in contact with horses are highly susceptible to horse-serum proteins. Such patients should not be treated with preparations containing horse serum if it can be avoided. If necessary to do so great care must be used in the administration.

Treatment.—It has not been demonstrated that serum disease or serum accidents can be entirely prevented. In ordinary serum sickness, which is the common type and follows the injection of serum for the first time, cold applications to the site of injection for the local swelling, and applications of calamine lotion containing 1 per cent phenol, or sodium bicarbonate baths, may be helpful to control the itching. Hypodermic injections of epinephrine hydrochloride solution 1–1,000 in 0.5 cc to 1 cc doses subcutaneously may give relief from the itching, swelling, and rash. In addition to the above measures free elimination, with sufficient intake of fluids, should be encouraged.

To prevent grave symptoms, as in serum accidents, an attempt should be made to elicit a history of previous administration of serum or a history of asthma or hay fever. Tests for sensitivity as mentioned later should be carried out and if positive the patient should be considered an unsafe subject for serum treatment by routine methods.

Desensitization offers a method of administering serum to many patients who would react violently to serum if given in the usual way. Patients who have asthma which is aggravated by coming in contact with horses may be so sensitive that they cannot be desensitized, but most of those whose hypersensitiveness dates back to a previous injection of serum can be treated with the usual amount without danger. Patients who have a history of

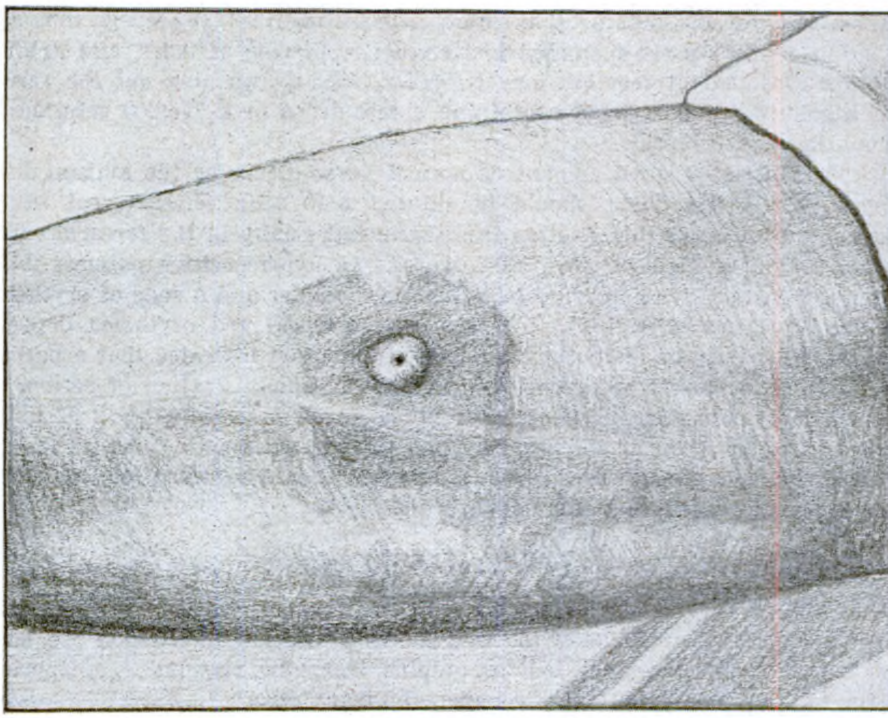

FIGURE 133.—Positive reaction to horse serum 10 minutes after intradermal injection of 0.1 cc of 1–10 dilution of horse serum. This reaction would be classed as moderate.

asthma or have a strongly positive skin test, should be given the first desensitizing dose subcutaneously. Beginning with 0.005 cc to 0.025 cc the dose may be doubled every half hour until a dose of 1.28 cc is given (ninth dose). Then 0.1 cc is injected intravenously and the dose should be doubled every 20 to 30 minutes until the required amount is given. Dilution with physiological salt solution 1–10 is advisable when unrefined serum is used.

With patients showing mild skin reactions, which is often the case when persons have had previous serum treatment, desensitization may be shortened by starting with a larger dose and increasing the size of subsequent doses. One should always keep on hand, when administering serum, a syringe containing epinephrine hydrochloride solution 1–1,000.

The symptoms of serum sickness must be treated promptly should they arise. Administration of serum must be stopped immediately and a tourniquet applied about the site of injection if possible to do so. Epinephrine hydrochlo-

ride solution 1–1,000 in 0.5 cc to 1 cc amounts should be injected subcutaneously and repeated at short intervals, if necessary, until relief is obtained.

Site of injection.—Many physicians prefer the muscular region on the outer area of the thigh for injection of serum because a tourniquet may be easily applied above the site, if necessary, to retard the process of absorption in case serum reactions occur. Serum that is given intramuscularly is less liable to be followed by serum reactions, due to slower absorption and thus serving to desensitize, than when given by the intravenous or intraspinal routes.

Sensitivity tests may be either conjunctival or dermal (skin).

In the conjunctival test several drops of a 1–10 dilution of normal horse serum are instilled into the conjunctival sac by retracting the lower lid gently and instilling the serum into the outer canthus or angle of the eye. A positive reaction will appear within 20 minutes, manifesting itself by congestion and dilatation of the vessels, increased lacrimation or flowing of tears, and itching. A severe conjunctival reaction may be neutralized by washing out the serum with a solution of boric acid containing a few drops of a 1–4,000 solution of epinephrine hydrochloride.

In the skin test a small amount of normal horse serum or the antiserum to be used in the treatment should be diluted 1–10 with physiological saline solution and 0.1 cc. of this dilution injected intradermally in the forearm. The reading should be made in 15 to 20 minutes. In hypersensitive patients there will be a wheal or hive approximately 1 cm. in diameter and a zone of erythema considerably larger (fig. 133). The size of the wheal and erythema depends upon the sensitivity of the patient. A positive reaction indicates that a patient is sensitive and should be desensitized before the administration of serum.

Rabbit serum may be substituted for horse serum in certain types of pneumonia treated by serum in the event hypersensitivity tests with horse serum are positive. Prior to giving rabbit serum the patient should be tested for sensitivity using the same procedure as for horse serum.

DRUG ALLERGY

Drug allergy may be defined as a condition of hypersensitiveness to certain drugs among which are some of the well-known drugs now in common use, such as arsenic, mercury, bromides, iodides, quinine, morphine, strychnine, antipyrine, aspirin, sandalwood oil, balsam of copaiba, and many others.

In most cases the symptoms of drug allergy appear within a few hours after the administration of the drug although the appearance of allergic manifestations may not appear until after prolonged administration. In some individuals prolonged administration of drugs causes no allergic symptoms but upon resuming treatment at a later date an immediate attack of hypersensitiveness is brought about. This may persist for some time or disappear completely.

One of the most common symptoms of drug allergy is fever, which in some cases is preceded by a chill. Temperatures as high as 104° to 108° F. have been recorded. Various forms of eruptions may occur, the most common are the erythematous or redness, the urticarial or hives, the vesicular or blister, the macular, spotted or blotchy, the papular or pimple, and the hæmorrhagic. Fever may not be present during the eruption nor may the eruption be present during the fever. Other symptoms less frequently noted are œdema, a painless swelling, especially of the face or at the site of injection; swelling of the joints, and in some cases swelling of the lymph glands.

The clinical characteristics of drug allergy are readily recognized as the same as those of serum disease. But for the chemical difference between serum

and drugs, serum allergy or serum disease and drug allergy would have been identified as the same disease.

It is important to remember that sensitivity to drugs may be detected by skin tests. Such tests are carried out by the scratch or patch method using the same technique in preparing the skin as described elsewhere in this section. A small amount of the drug, either in powder or solution, is rubbed into the scratch or applied to the skin, if using the patch test. The reaction to the scratch test may occur at any time from 10 minutes to 24 hours, usually less than 24 hours. The reaction to the patch test occurs somewhat later than the scratch test, usually between 2 and 24 hours.

BACTERIAL ALLERGY OR HYPERSENSITIVENESS OF INFECTION

A state of allergy may develop in any bacterial infection which has become chronic or which, with antigenically identical bacteria, is frequently repeated. The infectious exanthematous rashes such as scarlet fever, the syphilides and tuberculides are examples of allergic reactions. The tuberculides are typical examples of bacterial allergy and are associated with a high grade of resistance to the infection. Erythematous reactions of various types are found associated with a number of infections and should be regarded as allergic cutaneous reactions.

Erythema nodosum, a skin disease characterized by red, smooth, and shiny nodules on the shins, is found occasionally in tuberculosis, syphilis, acute streptococcal tonsillitis and acute rheumatism. Erythema multiforme, another skin disease characterized by a rash of various types is also considered to be an allergic reaction.

Obvious foci of infection, especially in the teeth, tonsils, and sinuses, should be eradicated. Urticaria, angioneurotic œdema and asthma have responded to the eradication of foci of infection. Occasionally bacterial allergy complicates a case of hay fever or asthma due to other allergens.

A group of generalized cutaneous allergic reactions occurs in fungus infections. The prevalent ring-worm infections of the feet and hands, particularly between the toes and fingers, frequently provokes an allergic response in the tissues and they often resist all forms of local treatment applied to the site of the infection.

The common fungi responsible for this condition are the trichophyton, epidermophyton, and monilia. Skin testing with extracts of the various types followed by desensitization with the specific type of fungus has given favorable results in many cases.

Tuberculin tests.—Evidence of bacterial allergy is best shown in tuberculosis. Cutaneous tests with tuberculin do not show the immediate wheal seen in pollen allergy but show a delayed reaction, the maximum reaction coming on some hours after the innoculation.

The most satisfactory tuberculin test is the intra-cutaneous one known as the Mantoux test. The antigen used in this test may be the purified protein derivative known as Tuberculin P. P. D. or the more familiar Old Tuberculin known as O. T. Purified protein derivative is furnished in tablet form in two strengths. Individuals who do not react to the first strength are reinjected 48 hours later with the second, stronger tablet.

The flexor surface of the arm is cleansed in the usual manner and 0.1 cc from the vial labelled first strength is injected just beneath the first layer of skin using a tuberculin syringe and number 26 gauge needle, approximately one-half inch long. The reactions should be read 48 hours after the injection.

The test is read as follows: A negative reaction shows no swelling and little redness or tenderness; a positive reaction (Fig. 134) may be classified according to size, a 1-plus consisting of an area of swelling measuring 5 mm. to 10 mm. in diameter, a 2-plus from 10 to 20 mm., a 3-plus over 20 mm. in diameter, and a 4-plus an area of swelling and necrosis; a doubtful reaction is one characterized by a trace of swelling measuring 5 mm. or less in diameter. In interpreting reactions swelling is more important than redness.

The first test dose of P. P. D. corresponds to 0.1 cc of a 1–25,000 dilution of Koch's Old Tuberculin. The latter may be used if desired, but owing to the uniform potency of P. P. D. a large number of extensive reactions previously seen with old tuberculin are eliminated and the purified form is now preferred.

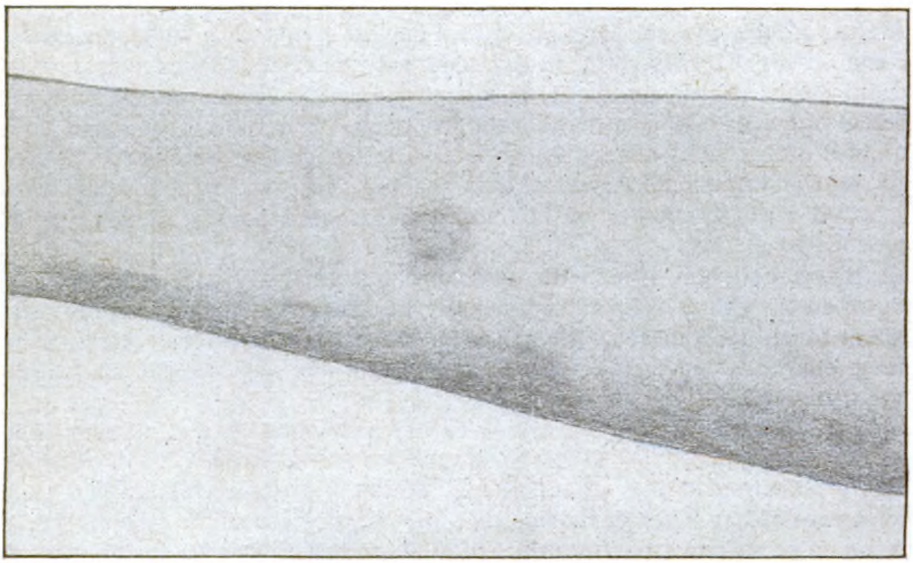

FIGURE 134.—Positive tuberculin test 72 hours after intradermal injection of 0.1 cc of First Test Strength of Tuberculin, P. P. D. (purified protein derivative).

In Von Pirquet's test a drop of Koch's Old Tuberculin is placed on the forearm and a slight scratch made through the drop. A control consisting of a drop of 50 per cent glycerin is placed several inches from the first drop containing the tuberculin, the skin being scratched in a similar manner. If the test is negative both areas will be the same size. If positive the drop containing the tuberculin will cause redness and swelling while the other will show no such reaction.

Moro's percutaneous test consists of rubbing into the skin over the chest or abdomen an ointment consisting of 50 per cent old tuberculin in lanolin. An area of approximately 4 inches may be used. If positive a reaction is shown by an eruption of papules over the area in 2 to 7 days. A rubber finger cot should be used in applying the ointment.

Recently Wolff devised a test similar to the Moro test using a small drop of the ointment and a drop of ointment containing no tuberculin. The drop is not rubbed in but covered, as in the patch test mentioned under contact dermatitis. The test is read in 48 hours producing papules similar to those of the Moro test when positive.

Other tests which may lead to unpleasant reactions and have no advantages over the previously described cutaneous tests are the subcutaneous test and Calmette's conjunctival test.

ALLERGY TO PARASITES AND INSECTS

Parasites in the intestinal tract or the body tissues may produce various allergic disturbances.

Ascarides (round worms), tape worms and ecchinoccocci in particular have been known to cause allergic disturbances.

The bites of fleas and lice produce manifestations.

Inhalants such as the emanations from flies, moths, and butterflies may also produce symptoms referable to the upper respiratory tract.

PHYSICAL ALLERGY

Duke states that many nasal, bronchial, cutaneous and other allergy-like manifestations may arise from the effects of light, heat, cold, and effort on the body cells.

Localized or generalized urticaria is the most common single symptom of physical allergy and is not often lacking.

The cause for this condition is not definitely known; however, experiments lend weight to the conception that urticarial wheals and probably some of the other manifestations of physical allergy are but normal responses to the presence of histamine or, as Rowe states, the physical agent may act as a trigger mechanism which releases an underlying potential ingestant, inhalant, or possibly a bacterial sensitization.

ELIMINATION DIETS (ROWE)

Diet 1	Diet 2	Diet 3	Diet 4
Rice. Tapioca. Rice biscuit. Rice bread.	Corn. Rye. Corn pone. Corn rye muffin. Rye bread. Rye crisp.	Tapioca. White and sweetpotato. Lima bean potato bread. Soya bean lima bean bread.	Milk.[1]
Lettuce. Spinach. Carrot. Beet. Artichoke. Lamb.	Tomato. Squash. Asparagus. Peas. String beans. Chicken. Bacon.	Beets. Carrots. Lima beans. String beans. Tomato. Beef. Bacon.	
Lemon. Grapefruit. Pears.	Pineapple. Peaches. Apricots. Prunes.	Lemon. Grapefruit. Peaches. Apricots.	
Cane sugar. Wesson oil. Olive oil. Salt. Gelatin. Syrup made of maple sugar or cane sugar flavored with mapeline or maple sugar. Olives. Pear butter.	Cane sugar. Mazola oil. Wesson oil. Salt. Karo Corn sirup. Gelatin.	Cane sugar. Olive oil. Wesson oil. Gelatin. Salt. Olives. Maple syrup or syrup made with cane sugar flavored with maple.	

[1] Milk should be taken up to 2 or 3 quarts a day. Tapioca cooked with milk and milk sugar also may be taken.

NOTE.—Wesson (Cottonseed) Oil is included in all diets. With allergy to cottonseed as shown by skin test or history this must be excluded and a cottonseed-oil shortening must not be used. If allergy to cane sugar is suspected, beet sugar or corn glucose may be used.

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Illustrations (figs. 130 to 134 incl.) by Glen Leith, Vallejo, Calif.

Section 3.—GENITOURINARY AND VENEREAL DISEASES

The male genitourinary system.

In the male the genital and urinary systems are so closely associated, both anatomically and functionally, that they are often referred to as one system, the genitourinary.

The anatomy of the different structures comprising these systems has been described in the chapter on Anatomy and Physiology.

DISEASES, INJURIES, AND ABNORMALITIES OF THE MALE GENITALIA

The most common diseases of the **penis** are *chancre, chancroid, gonorrhœa, cancer, tuberculosis,* and *elephantiasis* of the foreskin. Injuries include *crushing, laceration, fracture,* and *complete loss* by cutting or crushing. A *urinary fistula* is a false passage from the natural urinary passage in the penis to the external surface and usually follows abscesses of the urethra or injuries.

The **scrotum** has few diseases. The more common are *elephantiasis*, in the tropics, *cancer*, and sometimes *chancre* and *chancroid*. Injuries of the scrotum are usually lacerations or bruises.

The **testes** ordinarily have the following diseases: *Syphilis (gumma), mumps,* and *tumors*. The testes are rarely attacked by the gonococcus and tuberculosis, and are rarely injured except intentionally, in mutilation, which may be self-inflicted.

The **epididymis** is most commonly infected with *gonococcus* and next with *tuberculosis* and finally with ordinary *pus germs*. In some instances it is attacked by *syphilis*. It is rarely injured, excepting in grave injuries which involve the testicle. It may have tumors in rare cases.

The **vas,** the **prostate,** and the **seminal vesicles** are most frequently attacked by the *gonococcus, tuberculosis, ordinary pus germs,* and sometimes by *syphilis*. The prostate has, in addition, *cancer* and an enlargement which obstructs urination in old men is called *hypertrophy*.

Varicocele is an enlargement of the veins of the **spermatic cord.**

Hydrocele is a condition in which the sac surrounding the testicle is filled with a watery, serous fluid. It may reach an enormous size.

Hœmatocele is the same as hydrocele, except that the fluid is blood.

Undescended testicle may mean that the testicle is within the abdomen (it descends normally in the seventh month of fœtal life), or it may have stopped in the groin, or it may hang on the corner of the pubis.

Epispadias is a malformation of the penis in which the urethra opens on the top.

Hypospadias is a malformation in which the urethra opens underneath the penis.

Hermaphrodites are unfortunate individuals who have faulty development of the genitalia and partake of the characteristics of each sex, so that in extreme cases it is difficult to determine to which sex they belong. There is doubt if there is ever a true hermaphrodite, as this would depend on careful study and proving the presence of both true ovary and true testicle in the same individual.

Pyelonephritis and *pyonephrosis* are infections which involve the pelvis of the kidney. When the pelvis alone is involved it is termed *pyelitis.*

Ureteritis, cystitis and *urethritis* are conditions which indicate inflammation of these organs, the result of infection, chemical injury, or traumatic injury.

Stones or *calculus formations* may be found anywhere in the urinary tract.

In general the treatment of the foregoing lies beyond the scope of the hospital corpsman. However, there are a few conditions and treatments of which mention must be made.

Phimosis is a deformity of the foreskin which renders its retraction behind the glans, or head of the penis, impossible because of the small opening in the foreskin. The condition often induces an attack of balanitis or balanoposthitis. The remedy is circumcision, but if no medical officer is available for several days it should be cut on top; using injections of 1 per cent procaine or novocaine for anæsthesia. The cut can be made with a sturdy, sharp pair of scissors or with a knife on a grooved director which has been passed between the foreskin and the glans, being sure that the director is above the glans and not in the urethra. Care must be exercised to avoid cutting the glans and the cut should be extended far enough back so that the foreskin can be pulled back and everything seen. Bleeding can easily be stopped by tying off the bleeding points with catgut or silk ligatures.

Paraphimosis is a condition in which a tight foreskin has been retracted behind the head of the penis and cannot be brought forward readily. The small opening in the foreskin forms a band of constriction on the dorsal surface of the penis, which, interfering with the circulation of the blood, causes more or less deformity of the organ from œdema. The condition causes great discomfort and if neglected may go on even to ulceration and gangrene of the foreskin and head of the penis, with possible loss of the glans.

The first requirement of treatment is the immediate reduction of the displaced foreskin. This often can be accomplished in the following manner:

With the two thumbs pressing on the head of the penis at either side of the meatus, and the index and middle fingers behind the constriction, the blood is pressed out of the head, which being thus reduced in size and softened, is pushed back through the constricting ring and the foreskin drawn forward.

Should this procedure fail, owing to the tightness of the constriction, and the head of the penis shows great swelling and purpling, the tight constricting band must be found and a small longitudinal incision made completely through it on the dorsal surface, under local anæsthesia, so that the foreskin may be brought forward. The wound should be dressed with sterile gauze.

In *injuries* to the penis, scrotum, and testicle, bleeding may be dangerous, and if no medical officer is available an effort must be made to stop it. The first thing is to give morphine by hypodermic, at least one-quarter grain, repeated in a couple of hours if necessary, to quiet excitement. As a rule

do not put on a tourniquet, but try to find the bleeding points and then clamp and ligate them with catgut. Tourniquets may destroy the only chance of saving the part, because they shut off all the blood supply.

In cases where rings, wire, rubber bands, etc., have been placed around the penis, they must be cut or filed off at once; otherwise the swelling may produce gangrene and complete loss of the part.

If too strong solutions are introduced into the urethra by accident, give morphine, at least one-quarter grain, by hypodermic at once. In general pass no instruments, but inject gently plenty of sterile water. If the solution was lye or other alkali and the condition is seen early, inject vinegar or acetic acid, one-half of 1 per cent. Again, if the solution was nitric or sulfuric or some other acid, inject a solution of sodium bicarbonate, a teaspoonful to a pint. If phenol, inject magnesium sulfate, a tablespoonful to a pint. Bichloride of mercury is neutralized with the white of an egg. Iodine is neutralized with starch water. An ice bag will help keep down swelling. The services of a medical officer should be obtained as soon as possible.

THE VENEREAL DISEASES

The venereal diseases are those contracted almost always through sexual intercourse and include syphilis, gonorrhea, chancroid, and lymphogranuloma, venereum. These diseases are very prevalent in every community and do a great deal of damage not only to the individuals affected but to the community by reason of invalidism and premature death. In a military service the venereal diseases cause much loss of efficiency. In the year 1917 the British Army lost the services of 98,000 men as a result of venereal disease. During the same year the total number of admissions from venereal disease in the United States Army was 71,955, resulting in 875,553 sick days. In the United States Navy during the 9 years 1909 to 1917, inclusive, an average of 158 men out of every 1,000 were admitted to the sick list for venereal disease.

It is highly probable that every person who indulges in promiscuous sexual intercourse sooner or later acquires one or several of the venereal diseases. It has been estimated that 60 per cent of the adult male population of the United States have had gonorrhea. Now that routine Wassermann tests are made in many large civil hospitals, it is found that from 20 to 30 per cent of all admissions give a positive reaction indicating syphilis.

In 1917, in a large Pacific coast city, 97 per cent of the prostitutes were found to be infected with venereal disease. In a city on the Atlantic coast, 96 per cent of the prostitutes had venereal disease. These statistics may serve as an index of the prevalence of venereal disease among persons who practice promiscuous sexual indulgence.

The effects of venereal disease are far-reaching. In the case of syphilis the effects are in the beginning slight and local, but as the organism which causes the disease spreads throughout the body they become grave. One great danger is that early in the progress of the disease the symptoms are often so trivial that no anxiety is aroused in the patient's mind. The symptoms may be so slight as not to be observed. The patient may not seek treatment and he may succeed in unknowingly infecting other people.

When the infection becomes generalized every organ and every system in the body may be attacked. Syphilis is especially liable to attack the walls of the arteries. When this occurs the muscular portion of the artery often is replaced by nonelastic fibrous tissue. The artery becomes thickened and hardened. Hardening of arteries is a natural process which accompanies advancing age, but the hardening process resulting from syphilis is much more rapid and dangerous

as far as life is concerned. If the arteries of the brain become thickened and hardened the blood supply is diminished and the portion of the brain supplied with blood by the artery affected ceases to exercise its function. What the symptoms will be depends upon what part of the brain is involved, but the condition may cause mental debility, insanity, loss of speech or memory, or paralysis. Syphilis frequently attacks the aorta, the great artery leading from the heart. A part of the wall of the aorta becomes thickened and loses its elasticity by the formation of fibrous tissue which is weaker than the muscle in the wall of the vessel. The force of the blood stream causes a bulging of this weakened part and in time the wall becomes thinner and the bulging greater until eventually a distinct pouch is formed. The bulging of an artery in this manner is known as an aneurysm. The thinning of the wall makes the aneurysm very liable to burst. This often happens and the patient dies suddenly. Syphilis frequently causes disease of the heart or other important internal organs.

Perhaps the most important part of the body attacked by syphilis is the nervous system. Either the brain or the spinal cord, or both, may be affected. Once the organism of syphilis has lodged in the nervous system it is extremely difficult to evict it. A man with syphilis, if he marries, may infect his wife, and a child born after the infection is apt to show grave manifestations of the disease. Syphilis is a most frequent cause of miscarriage in pregnant women.

The local inflammation of the urethra, which is all that most patients see in gonorrhœa, is actually the least of its dangers. Apart from the danger of infection of the eyes and the general infection of the body resulting in heart disease and gonorrhœal rheumatism, the complications due to direct extension of the disease are different in the two sexes. In man all of the organs connected with the genito-urinary tract may become infected. In women grave complications are common. Invasion of the uterus, the Fallopian tubes, and the peritoneum by the organism is frequent. This invasion takes place either shortly after infection or after the birth of the first child. The gonorrhœa may subside and become quiet in the glands of the mucous membrane of the vagina until pregnancy excites a congestion that increases the virulence of the bacteria causing the disease. By these virulent organisms the child's eyes are endangered at birth; its mother's uterus and Fallopian tubes immediately thereafter. It is estimated that in 10 per cent of blind children the blindness is due to gonorrhœal infection of the eyes during birth. Over 60 per cent of the inmates of asylums for the blind are made blind by gonorrhœa. Gonorrhœa of the uterus and Fallopian tubes usually makes a woman sterile—that is, unable to conceive children. Besides depriving a woman of her children, gonorrhœa may render her a permanent invalid—may even cost her her life. It is a curious fact that gonorrhœa in women is either much milder or much more severe than the disease in man. Some women while heavily infected have few or no symptoms of the disease and are not inconvenienced by it. Others are overwhelmed by gonorrhœal abscesses in the Fallopian tubes, in the pelvis, or by peritonitis. They must undergo severe surgical operations or die; should they recover they often are invalids the rest of their lives.

Syphilis.

This is a generalized, chronic, infectious disease that attacks any and every part of the human body. It occurs in two forms, *acquired* and *hereditary.* Acquired syphilis is communicated by a syphilitic person to one free from the disease, the point of inoculation always being marked by a sore called the initial lesion or *chancre.* Hereditary syphilis is transmitted to the unborn child from one or both of its parents; in this form there is no initial lesion,

the onset of the disease being marked by general manifestations which may be noticed at the time or shortly after the syphilitic child is born.

The **cause** of syphilis is the *Treponema pallidum*, a microörganism belonging to one of the lowest families of the animal kingdom, the *Spirochætaceæ*, or spirochætes. This organism is shaped like a corkscrew sharpened at both ends, is very active, and is very easily killed by heat, drying, sunlight, and antiseptics; its **transmission** is easy by sexual intercourse, and it is not infrequently transferred by the kissing, biting, and scratching of infected persons, or the use of the toilet articles, eating, drinking, or smoking utensils, pencils and pens, etc., of infected persons with open lesions. It may also be transferred through the handling of open lesions. While it is believed that there must be at least a slight break in the skin for its entrance, there is no certainty that such a break is necessary.

Acquired syphilis, to which this discussion will be confined, is usually divided into three stages, the primary, the secondary, and the tertiary. The *primary stage* consists of two periods of incubation, the first of which exists from the time of exposure to the appearance of the initial lesion and, as a rule, lasts from 14 to 21 days but has been noted within as short a time as 3 or 4 days and as late as 4 months. This is followed immediately by the second period of incubation which dates from the formation of the initial lesion to the development of certain constitutional manifestations and usually occupies from 40 to 45 days but may be prolonged much longer. The initial lesion, primary sore, or chancre appears on the penis, scrotum, or elsewhere. Usually there is but one sore which is a hard and cupped-out ulcer showing a tendency to heal slowly and giving little if any pain. These sores vary greatly in their character and some are so small and insignificant that they escape the notice even of cleanly persons. The near-by lymph glands are swollen, but not painful or tender, and do not tend to form pus. Blood tests in this stage are seldom positive. The *secondary stage*, or secondaries, is characterized by the appearance of the constitutional manifestations consisting of any or all of the following: Rashes on the skin, superficial lesions on the mucous membranes, general enlargement of the lymph glands, headaches, fever, pain in the bones, muscles, and joints, and falling hair. The duration of this stage is variable, usually being from 1 to 2 years, and in it the blood tests for syphilis are generally positive. Should the result of the first blood test be negative repeat tests should be made at intervals for at least 1 year after the appearance of any suspicious lesion, particularly one located on the genitalia.

The *tertiary stage* usually begins at about the end of the second year but may not appear for years after symptoms of the secondary have disappeared. It is not seen so frequently today as formerly because of modern methods of treatment. It manifests itself by tumor-like swellings called gumma, destructive lesions in the nose and other parts of the body, affections of the heart and blood vessels, liver, kidneys, bones, and sometimes of the nervous system, the latter producing paralysis, insanity, etc. Tertiary manifestations may simulate every symptom known to medicine.

The **treatment** of syphilis should be begun just as soon as a positive diagnosis is made, even if the disease is still in the chancre stage. The prognosis is much better if efficient medication is given before the organisms have had an opportunity to produce tissue changes throughout the body.

Although the details of treatment cannot be fully gone into here it may be stated that it consists principally of the administration of salvarsan, mapharsen, neosalvarsan, silver-arsphenamine, tryparsamide, and sulfarsphenamine, all belonging to the arsenical group, the first five being injected into the veins, and

the latter being injected deep into the buttocks. Mercury is given by mouth, by inunction, and by injection deep into the buttocks, bismuth subsaliscylate is injected deep into the buttocks; iodide of either potassium or sodium usually is given by mouth, and the latter sometimes into the veins.

The disadvantages and dangers of these substances will be mentioned under a paragraph devoted to that subject.

Local treatment amounts to very little, and no antiseptic should be put on a primary sore until the sore is definitely diagnosed. Dress it with warm physiological salt solution only and do not even use soap, because this and antiseptics interfere with finding the microörganism.

Every case with open sores should strictly adhere to the use of their own clothing, towels, bedding, pipes, toilet articles, etc., and separate toilet seats and separate mess gear should be provided. If possible they should be kept in separate wards and should not be allowed to go on liberty. All dressings should be burned and hospital corpsmen dressing such cases should wear gloves, especially if they have any cuts or scratches on their hands. If gloves are not available, the hands should be washed thoroughly with soap and water immediately after dressing the case. They should not skylark or wrestle with such patients. If a medical officer or hospital corpsman should cut or prick his finger while working with these cases the wound should be cauterized at once which will practically always prevent infection. An entry of such an accident should always be made in the health record of the individual concerned.

The diagnosis of syphilis in the primary stage is made by demonstrating the infecting organism in smears from the chancre by means of dark-field illumination. This method is described in the section on Laboratory Procedures and Technique.

The blood tests used in the diagnosis of syphilis are possible because of the characteristic changes in the blood serum as a result of the invasion of the spirochætes, and are known as serological reactions. In them the serum of an infected person reacts specifically with certain substances from normal tissues. Principal among these tests are the Kahn flocculation test and the Wassermann complement fixation test, the details of which are too technical to be given here. There are many other tests, such as the Noguchi, Emery, Kline, Hinton, etc.

Changes may occur in the cerebrospinal fluid of persons infected with syphilis and positive Kahn and Wassermann reactions with it can also be obtained. There are other tests of the cerebrospinal fluid that may be used in the diagnosis of syphilis.

In some instances there may be repeated positive serological reactions without history, symptoms, or other signs. In such cases the diagnosis of *Syphilis, sero-positive only,* should be used in reporting the condition.

With treatment the reaction in these tests usually grows weaker and finally becomes negative, but many cases responding well to treatment never become negative.

It should be remembered that there are some other diseases that will give positive Kahn and Wassermann reactions, of which one is yaws.

Chancroid.

This is an ulcerative type of disease whose action is local in character, not generalized like syphilis, being limited to the parts where it occurs and related lymph glands. The word means "like a chancre," and nearly always occurs in those who are most uncleanly in their habits, being preeminently "a disease of dirt and filth."

The cause of chancroid is undoubtedly the *Hæmophilus ducreyii* (Bacillus of Ducrey) which is often called the streptobacillus of Ducrey because it occurs in the form of short rods end to end like a chain until ulceration sets in. Its **transmission** is commonly by sexual intercourse and it may be transferred by inoculation in an abrasion of the skin of another person or of the person already infected, as the secretion of a chancroid is highly infectious. Chancroid nearly always occurs on the genitals, occasionally in the anus or mouth in cases of perversion, and rarely on the hands, etc., by accidental infection. On the male genitals it is most common in the groove behind the penis, especially in the little pocket on each side of the frænum, but it may occur on the head of the penis, the inner surface and free border of the foreskin, and the skin covering the penis.

Chancroid is characterized by an ulcer that is usually painful, tender, soft, prone to bleed easily, and has a tendency to spread and form secondary ulcers. These ulcers are likely to be phagedenic and destroy tissue, and may finally destroy the whole penis. The first ulcer usually begins as a small pustule surrounded by a highly inflamed area. The pustule soon breaks down and leaves a round or irregular ulcer with sharply defined edges and undermined walls. The floor of the ulcer is rough and generally is bathed by a purulent secretion which is very infectious. There is a varying amount of inflammatory thickening of the tissues around and beneath the sore, which shades off gradually into the surrounding parts, thus differing from the ring-like induration of the syphilitic chancre which is hard and sharply outlined. The chancroid is prone to form buboes which are painful and tender, and usually form pus. The chancroid has no fixed period of incubation, its development is rapid, and it usually appears in 2 to 5 days after infection.

In addition to forming buboes chancroid may be complicated by mixed infection with syphilis and with pyogenic organisms, by destruction of the frænum, by phimosis, balanoposthitis, etc.

The **treatment** of chancroid should *never* be started until after the sore has been studied to make sure that it is not a chancre, because *it is always possible that any sore on the penis is syphilitic.* It should be dressed at first with warm physiological salt solution only, and repeated examinations of the secretions for the presence of *Treponema pallidum* should be made. When it is decided that the sore is a chancroid local treatment should be immediately started. There are many remedies but probably the best in order, would be copper sulfate, nitric acid, phenol, alum, chlorinated lime water, calomel ointment, etc. On account of pain it is usually necessary to apply a 4 or 5 per cent novocaine or procaine solution to the sore before carrying out the more drastic treatment. Although there may appear to be no syphilitic element present some very bad phagedenic chancroids may be healed by an intravenous dose or two of salvarsan which is probably due to the tonic effects of the arsenic in the salvarsan.

Gonorrhœa.

Acute anterior urethritis, or clap, as gonorrhœa is commonly called, is a local inflammatory disease usually affecting the mucous membranes of the urethra in the male and the urethra and cervix uteri in the female; by accident or perversion, the mucous membrane of the anus or mouth; and, by accident, the conjunctivæ of the eyes. It does not occur in any of the lower animals. The causative organism may extend and infect any part of the genito-urinary tract, and may attack joints, the valves of the heart, and even the meninges by entering and circulating in the blood stream. The word gonorrhea is a mongrel one from the Hebrew and Greek languages meaning "flow of semen," which is, of course, incorrect.

The **cause** is the *Neisseria gonorrhϾ* (gonococcus) which belongs to the family of bacteria known as the Coccaceæ, or cocci. When stained and viewed through the microscope they usually are seen in pairs, either within or outside of pus cells, and have the appearance of two coffee beans with their flat sides together. In the earliest stage of the disease, when the discharge is glairy, a considerable number may be seen lying free or adhering to the surface of cells thrown off from the inflamed mucous membrane, but when the discharge becomes purulent the large proportion within pus cells is very striking. The **transmission** of gonorrhœa of the male urethra may be said to be by sexual intercourse only, through the deposition of the gonococcus on the mucous membrane of the urethra during intercourse with a woman having the disease. Its transmission to other parts of the body is by the hands, towels, etc., or by perverted practices.

The usual manifestation of gonorrhœa of the urethra is a local inflammation of the infected surface which is characterized by redness, swelling, and exudation of pus at the outlet of the urethra as a creamy drop. During intercourse the gonococci enter the anterior part of the urethra and proceed to grow into the delicate lining membrane and set up an inflammation which becomes noticeable usually about the fourth day after exposure but may be as early as 24 hours or as late as 10 days. The first sign is usually a slight sensation of burning, itching, or pain about the urinary meatus, and sometimes a slight desire to urinate frequently. The pain or burning is most marked during urination owing to the irritation caused by the urine passing over the inflamed area. After a day or two a small quantity of glairy mucus can be squeezed out from the meatus, the lips of which now appear slightly reddened and have a tendency to stick together. The mucous stage lasts for about 24 hours after which the discharge becomes decidedly purulent in character, the pain is sharper and during urination there is a marked burning sensation in the urethra. The discharge becomes profuse, yellowish-green in color, creamy in consistence and sometimes tinged with blood, the lips of the meatus and often the entire head of the penis are bright red in color, hot, and swollen. In severe cases the lymphatics on the dorsum of the penis become swollen and painful, and as they communicate with the inguinal glands these latter may become enlarged and tender.

The infection spreads and the entire anterior urethra becomes inflamed. Every act of urination is now painful as the urine is forced through the urethra, whose caliber has been greatly lessened by the swelling of its mucous membrane. The pain may be so severe as to inhibit the passage of urine.

Painful erections (*chordee*) occur, especially at night, which rob the patient of his rest, and in this way cause debility, general malaise, and nervousness.

The symptoms increase in severity up to about the third week of the disease, and then in favorable cases gradually decline until at the end of about 6 weeks the patient is practically normal. The discharge almost disappears and the only reminder of the disease may be a little moistness at the meatus in the morning. The patient perhaps considers himself cured, but may find that any dietetic indiscretion, such as the drinking of alcoholic beverages or sexual intercourse, causes a reappearance of the symptoms.

The foregoing description refers to an uncomplicated and untreated case. Although the patient is free of symptoms, he is not cured. The disease merely has become chronic. The urethra has become tolerant to the gonococci which are still present, as generally can be shown by microscopic examination.

Chronic gonorrhœa, or gleet as it is sometimes called, is a serious matter. It is the man with chronic gonorrhœa who mainly is responsible for the spread

of the disease. The patient is quite unaware that he is in an infective state and he may marry without any misgiving. The gonococcus to which his urethra is practically immune is then implanted in the vaginal mucous membrane of his wife, and in this fresh soil takes on renewed activity. It not infrequently happens that such a man after a few weeks of married life finds symptoms of acute gonorrhœa developing in himself. He usually suspects his wife and serious domestic trouble may result. In reality all that has happened is that he has been reinfected by his own organisms which have become rejuvenated by their residence in the genital passages of his wife.

The gonorrhœal process rarely is limited to the anterior urethra. In about 90 per cent of all cases of acute gonorrhœa the infection passes quite quickly up the urethra to and beyond the region of the compressor or cut-off muscle of the urethra. When this locality is passed inflammation is set up in the posterior urethra.

This invasion of the deeper parts of the urethra may take place gradually and with such mild symptoms as to escape detection; but in the majority of cases it is indicated by a sudden and very marked decrease in the amount of discharge at the meatus, accompanied by frequent desire to urinate, with inability to hold the urine when the desire comes on.

In the mild cases involvement of the posterior urethra may be detected by means of the two-glass test, which is performed in the following manner:

The patient passes the greater part of his urine into one glass and the remainder into another. If the disease is confined to the anterior urethra, the urine in the first glass will be cloudy from the pus washed out of the anterior urethra, while in the second glass it will be clear, as it consists of normal urine from the bladder passed through a urethra which has been washed clean of pus. Should the posterior urethra be involved, however, the pus from it, escaping backward into the bladder, renders all the urine in it cloudy; the urine in both glasses therefore will be cloudy, the first a trifle more so than the second, as it consists of turbid urine from the bladder in addition to the anterior urethral discharge which it washes out.

Gonococci not infrequently enter the duct of the prostate gland, giving rise to an inflammation known as *prostatitis*, indicated by severe pain in the rectum which is generally intensified by defæcation. This inflammation may go on to the formation of an abscess which may burrow in various directions and burst into important near-by structures with serious results. The prostatic inflammation when chronic may give rise to an increase in the size of the gland. As the prostate surrounds the urethra just where it leaves the bladder, this increase in the size of the gland may interfere with the complete emptying of the bladder. The urine thus retained may decompose, become infected, and cause inflammation of the bladder. This inflammation may extend up the ureter and involve the kidneys, with serious results.

When gonorrhœal infection of the posterior urethra spreads along the vas deferens to the epididymis inflammation of that organ is set up. Such inflammation is known as *epididymitis*. About 5 per cent of all cases of gonorrhœa under treatment develop this condition. The patient first notices a slight tenderness along the course of the epididymis. Later on the pain becomes very severe, and the scrotum or bag in which the testicles hang, becomes swollen and puffy. Constitutional symptoms may be severe and the patient's temperature may rise to 104° F. With proper treatment after about a week of acute symptoms the condition begins to subside. Although the patient may not complain of either pain or discomfort, the epididymis has not returned to its normal

healthy condition, and the condition tends to become active again on the slightest indiscretion, such as getting out of bed too soon.

The important effect of an epididymitis is that the inflammation often causes the caliber of the epididymis to become narrowed or obliterated, with the result that spermatozoa no longer are able to pass from the testicle to the urethra. In other words, the patient has become sterile on that side. If there has been epididymitis on both sides the patient becomes completely sterile. He still retains his potency but the ejaculated fluid, mainly prostatic secretion, is scanty in quantity and is devoid of spermatozoa. Impregnation of the female is thus impossible, hence the unfortunate patient no longer can reproduce his species.

An important sequel of gonorrhœa is *stricture* of the urethra. By this is meant a narrowing of the urethra by scar tissue at the site of an ulceration set up by the gonococcus. The narrowing of the urethra interferes with the free flow of urine and in time may cause complete retention or inability on the part of the patient to pass his urine.

The **treatment** of typical gonorrhœa has been one of the open questions of medicine for a century. The ideal treatment would be to put a man to bed on a milk diet but this rarely is successful because few healthy men will keep it up for more than 5 or 6 days.

In the acute stage a patient must be kept quiet and all sexual stimulation avoided. For the first week or 10 days, or even longer if the symptoms of inflammation are very marked, the diet should be light and easily digested. The following articles should be excluded: Ham, bacon, red meats, green vegetables, fresh fruits of all kinds, condiments and spices, coffee, chocolate, cocoa, all alcoholic drinks, ginger ale, and similar effervescent waters.

By mouth, sulfanilamide is of value, but methenamine, salol, and other urinary antiseptics are of questionable value.

The testicles must be supported by a well-fitting suspensory bandage, which does not press upward on the urethra at the junction of the penis with the scrotum and thus interfere with the free drainage of the urethra. The head of the penis and the cavity of the foreskin must be kept clean by the frequent washing of these parts with hot water.

The penis should be so dressed as to allow free drainage of the pus from the urethra, which at the same time must be kept from the cavity of the foreskin, the patient's fingers, and clothing. These requirements are filled by a piece of gauze cut about 4 inches square, with a slit in the center through which the head of the penis is passed until the gauze rests in the groove behind the head. The foreskin then is drawn down over the gauze which protrudes from the orifice of the foreskin and catches the pus as it is discharged from the urethra. This dressing should be changed several times daily according to the amount of the discharge. If the foreskin is too short to hold such dressing in place, the end of the penis can be covered by a tobacco bag into which some gauze is placed. Never plug up the cavity of the foreskin with cotton or use cotton in a tobacco bag, as this interferes with the free discharge of pus and will favor the spread of the infection to the posterior urethra. To allay local pain and inflammation the penis should be immersed several times a day in hot water.

A hot sitz-bath relieves to a great extent the feeling of soreness in the perineum. This bath is indicated if the patient has difficulty in passing urine. The heat has a tendency to relax the inflamed parts and the urine may be passed directly into the bath water.

In all manipulations of the penis it is important to remember that the gonococcus when transferred to the eyes will set up a severe inflammation which may result in permanent impairment of vision.

As soon as a case of gonorrhœa comes under treatment the patient should be warned of the danger of infecting the eyes, the necessity of thoroughly washing the hands after handling the penis, and the danger of contaminating towels, etc., and in this way causing the infection of others.

The bowel should be kept freely open, preferably by vegetable cathartics, as saline purgatives are apt to produce more or less urethral irritation.

To render the urine bland and nonirritating the patient should drink water freely, a glassful every hour during the day and whenever he wakes at night. For the prevention of painful erections the patient should be instructed to empty his bladder just before retiring, to sleep on his side on a hard mattress, with as little covering as possible.

If awakened by an erection, he usually can obtain relief by emptying the bladder and by cold applications to the penis.

When in a few days, as a result of the above constitutional treatment, the very acute inflammatory symptoms begin to subside, as is indicated by a diminution and thinning of the urethral discharge, less pain on urination, and a decrease in the redness and swelling of the meatus, local treatment by injection, usually administered by the patient himself, may be instituted.

If the urethra was a straight, smooth tube, gonorrhœa would be easy to treat, but there are along the urethra numerous little pockets in which the gonococci are buried and consequently are difficult to reach with any solution injected.

Any injection should be gently done and the solution used should not be strong enough to produce more than a mere tingling; never a burning, painful sensation. Some men are very sensitive and the solutions must be diluted below the usual strengths.

The solutions commonly used are mild or strong protein silver (argyrol, silvol, and protargol), mercurochrome, potassium permanganate, etc., the strengths of which are given later.

Hand injections are given as follows: The patient urinates, wipes the meatus with a bit of gauze, gently inserts the nozzle of the syringe completely filled with the solution used into the meatus, the lips of which are lightly pressed together from side to side against the syringe; the solution then is forced in very slowly until there is a feeling of distention in the urethra. The solution should be held in the urethra 4 or 5 minutes, if not too uncomfortable, before being allowed to escape. Injections should be made three or four or even five times daily, and while the fluid is being injected the patient should contract the compressor muscle of the urethra, much as if he were trying to hold back the contents of the bladder, in order to prevent the passage backward of any of the medication into the posterior urethra. While the solution is in the urethra the penis should not be massaged or rolled.

If the foregoing treatment has been successful, in about 3 weeks the patient will have only a trifling urethral discharge, sometimes seen only in the morning, with flakes or shreds in the urine. At this stage the injection should be changed to a solution of zinc sulfate one-half of 1 per cent in strength, administered daily.

The patient should be warned against "stripping" or "milking" the penis in an endeavor to find a "morning drop." Such manipulation irritates the inflamed mucous membrane of the urethra and retards healing.

The patient's urine should be watched daily by the two-glass method described before and as soon as evidence of acute posterior urethritis develops all injections must be suspended.

The patient should be kept very quiet and, if possible, put to bed for a few days, on a light, nutritious diet with the testicles properly supported. The bowel must be kept freely open as any accumulation of fæces in the rectum is liable to irritate the inflamed deep urethra and the prostate gland.

Water should be taken freely. Hot water bags over the bladder or against the perineum relieve the pain in the deep urethra, as does the hot sitz-bath.

If retention of urine occurs, it should be relieved promptly by the hot sitz-bath, or if that measure fails, by catheterization with a soft-rubber catheter.

When the frequency in urination, bladder irritation, and other acute inflammatory symptoms begin to subside, the local urethral treatment may be carefully resumed and the patient allowed to be up and about.

There are several complications of acute gonorrhœa which require special treatment.

Balanitis is an inflammatory process attacking the mucous membrane of the head of the penis, and if accompanied by inflammation of the mucous membrane lining the foreskin, as it generally is, it is called *balanoposthitis.*

It is caused by uncleanliness or by allowing smegma or gonorrhœal pus to collect beneath the foreskin, where more or less inflammation is set up. The condition usually occurs in persons with a long tight foreskin, a condition which prevents retraction and proper cleaning of the parts. In treating this condition the parts must be kept clean by washing with hot water and separated by means of gauze wet in boric acid solution. When the acute process has subsided the parts may be treated by careful cleansing, drying, and the application night and morning of a dusting powder, such as thymol iodide. If the foreskin cannot be retracted, the space about the head of the penis may be washed out with hot water or physiological salt solution injected by means of a syringe. If there is considerable swelling of the parts the patient should be kept in bed with the penis enveloped by a wet dressing of physiological salt or boric acid solution. Soaking the entire penis in hot solution of boric acid, salt, or magnesium sulfate is useful.

Phimosis and *paraphimosis* have been previously discussed.

Epididymitis is one of the most frequent complications of acute posterior urethritis. The patient should be put to bed and given a brisk cathartic. The enlarged scrotum with its painful contents should be supported by a band of zinc oxide adhesive plaster 3 or 4 inches wide, which passes beneath the scrotum to each thigh, care being taken to have the thighs, legs, and inner borders of the feet close together before applying the plaster. If there is much hair on the thighs it should be shaved off to prevent pain when the plaster is removed.

The scrotum, supported as described, is surrounded with gauze which is kept wet day and night with boric-acid solution or a saturated solution of magnesium sulfate. When the acute inflammatory symptoms have subsided, as a result of treatment, 20 per cent ointment of ichthyol is spread over the scrotum, which then is surrounded by a layer of lint or nonabsorbent cotton, over which is placed a piece of oiled silk or impermeable paper, the whole dressing being kept in position by a snug suspensory bandage. The patient is allowed to get up 4 or 5 days after all pain, tenderness, and temperature have disappeared. If he is allowed out of bed too soon a recurrence of the symptoms is likely.

Prostatitis is an acute inflammation of the prostate gland and is a very common complication of acute posterior urethritis. When infected the gland becomes engorged with blood and swollen. This gives rise to a sense of fullness in the perineum and rectum, accompanied by irritation of the bladder. There is more or less pain in the prostate, as the fæcal masses press upon it as they pass through the rectum during defæcation. The finger, covered with a rubber finger cot, if introduced into the rectum finds the gland to be enlarged, hot, and painful.

A patient suffering from acute prostatitis should be put to bed immediately. All injections should be stopped and the urine rendered bland by copious drafts of water. The bowel should be moved freely every day, using vegetable cathartics for the purpose. Hot-water bottles over the bladder and against the perineum are useful. Much relief is obtained from the use of hot rectal irrigations of physiological salt solution given twice a day in the following manner:

The patient lies on his side with the buttocks near the edge of the bed or table. An irrigating can filled with saline solution at a temperature not over 115° F. is so suspended that its lower end is about 1 foot above the patient's hips. Two rectal tubes thoroughly lubricated with petrolatum are inserted very gently for a distance of about 3 inches in such a way that the outlet of one tube is near the gland. The fluid in the can is allowed to flow slowly into the rectum through this tube and out through the other which may have to be adjusted by withdrawing it a little to obtain a ready return flow. The posterior surface of the prostate thus is bathed with hot saline solution. Each treatment should last from 20 to 30 minutes.

Gonorrhœal ophthalmia is an infection of the eye caused by the accidential transference of gonorrhœal pus from the genitals to the eyes by means of the fingers, dressings, or towels. It is one of the most serious complications of gonorrhœa as it may result in either partial or complete blindness.

The symptoms usually appear within a few hours after infection and consist of redness and swelling of the conjunctiva, increased lacrimation, accompanied by intense itching and a feeling as if a foreign body were under the lids.

The conjunctivitis is associated with a profuse purulent secretion in which gonococci may be found on microscopical examination.

The eyelids rapidly become red and swollen and the patient is soon unable to open the eye.

The treatment may be divided into prophylactic and curative.

Prophylaxis consists in thoroughly cleansing the hands after administering treatment or after handling the penis, the sterilization of all instruments and the immediate burning of all dressings which have been soiled by gonorrhœal discharge.

When a gonorrhœal infection of an eye is suspected, the patient should be put to bed at once. If only one eye is affected, the sound one is covered with a glass shield to prevent its infection; this shield consists of a watch glass placed against a hole slightly smaller than the glass, in the center of a piece of adhesive plaster 4½ inches square; the adhesive plaster is fastened to the skin about the eye and nose. It is advisable to leave a small area of the plaster nonadherent at the outer edge of the eye to permit the evaporation of moisture from the skin, which otherwise would collect within the shield. If a glass shield is not available the noninfected eye may be protected by covering it with a clean dressing and bandage.

The infected eye must be washed out day and night with cold boric acid solution as often as any secretion accumulates. This flushing of the eye

should be followed by the instillation of a drop of 10 per cent mild protein silver solution (argyrol, silvol) into the eye. In the intervals between the washings the eye should be kept covered with cold compresses—squares of gauze taken from a block of ice if possible, and changed every 2 or 3 minutes. These gauze squares should be used only once and then burned. Rubber gloves should be worn when giving these treatments. The eye is flushed out by means of an irrigator held high enough to allow the cold boric acid solution to flow out in a gentle stream.

The patient should be gotten to a medical officer as quickly as possible.

By the foregoing methods of treatment the hospital corpsman cannot expect to cure a gonorrhœal infection, but by adhering to the treatment advocated he can relieve his patient of many distressing symptoms and shorten the time required by the medical officer to effect a cure.

Lymphogranuloma, venereum.

This so-called "fourth venereal disease" is a subacute infectious condition involving chiefly the inguinal region, and also the prepuce, perineum, or vulva. It affects both men and women and is more common in tropical than in temperate climates.

The **cause** of this disease is very probably a filtrable virus although the specific etiological agent has not as yet been demonstrated. Its **transmission** is by direct contact and almost exclusively by sexual intercourse. The discharges or secretions from lesions are infective.

The disease is characterized by a small primary herpetiform lesion on the genitalia followed by inguinal lymphadenitis, usually with a multiple source of suppuration, and not infrequently associated with constitutional symptoms such as fever, anorexia, loss of weight, and prostration. It first manifests itself, from 1 to 4 weeks after exposure, by the appearance of a small, superficial ulceration on the external genitalia. The primary lesion is usually painless, and transient, disappearing in a few days, and may be so small as not to be detected. About 1 or 2 weeks later glandular enlargement occurs, the inguinals in male and the deep pelvic perirectal glands in the female. The enlarged glands vary in size from that of a small lime to that of an orange and may be involved singly or in chains, frequently bilaterally. Later central softening and suppuration occurs with the formation of indolent, discharging sinuses.

Constitutional symptoms are variable. Fever, prostration, loss of weight, rheumatic affections and skin reactions have been observed. Elephantiasis of the penis and scrotum may occur due to blocking of the lymph spaces by inguinal adenitis.

The clinical syndrome of lymphogranuloma, venereum in women has been classified into three types: 1. Anorectal elephantiasis; 2. Rectal stenosis and stricture; and 3. Pelvimetritis with secondary rectal stricture.

Various **therapeutic measures** have been recommended; physical, chemical, and surgical. A specific has not been found. Sulfanilamide has proved a valuable adjunct to therapy. It aids in the healing of ulcerations and helps draining buboes to cease. Good results have been obtained by the administration of iodine or antimony preparations.

Roentgen irradiations and ultra-violet light have been used with variable, and in most instances inconclusive, therapeutic response.

Frei antigen, diluted four times, and administered intradermally, at intervals of 5 days, has demonstrated encouraging results.

In the diagnosis of lymphogranuloma, venereum the Frei antigen intracutaneous test is widely used. The antigen consists of pus from a bubo heated to 60° C.

for 2 hours on one day and for 1 hour on the following day. Intracutaneous injections of 0.1 cc in the forearm give rise in an infected person to an inflammatory, dome-shaped area at least 0.5 cm. across with a small central infiltrated papule. The reaction reaches its height after 48 hours.

This disease must be differentiated from granuloma inguinale which is primarily a disease of the skin and not caused by a filtrable virus. Donovan inclusion bodies found in the smear from the ulcer are characteristic of this condition.

Because of the frequency with which they occur on the genitalia the two conditions next named are included here.

Verruca accuminata, venereal.

Venereal warts usually appear as small growths springing from the mucous membrane of the head of the penis or the inner surface of the foreskin, the region of the frænum or the margin of the meatus. They are not necessarily venereal. Their cause usually can be traced to irritation incident to prolonged contact with inflammatory discharges. Thus, in the uncleanly with long foreskins, in those suffering from gonorrhœa or chancroid, these growths are not uncommon. The redundant or phimotic foreskin which prevents proper cleansing is an important predisposing cause.

The **treatment** consists of complete removal of the growth with possibly circumcision, and this is the only reliable treatment.

Herpes.

This is a condition which is not venereal but which is mentioned in this connection because of its frequency and the liability of its confusion with venereal sores. This affection is characterized by the rather sudden appearance of small blisters upon a reddened base. Commonly they appear in or about the groove behind the head of the penis, involving both the head and the foreskin. The blisters quickly break leaving rounded or irregular erosions or ulcers which may run together forming a ring of ulceration around the penis.

Sometimes these blisters are accompanied by intense pain, and the pain may precede the development of the blister.

Herpes having once appeared is prone to develop again; at times the recurrence quickly follows the first attack, new crops of blisters forming as fast as the earlier lesions are healed. More frequently there is a distinct interval between the attacks.

The lesions should be kept clean and protected with dressings of physiological salt solution which allows repeated examinations to be made for possible chancroidal or syphilitic infection.

INSTRUMENTATION

In genitourinary and venereal diseases.

It is not expected that hospital corpsmen will give intravenous treatments or pass sounds, but they should be familiar with the instruments and their care, the preparation of the patient and his after care, and be able to do ordinary catheterization.

The equipment for the administration of mercury, bismuth, and sulfarsphenamine by hypodermic injection and salvarsan, neosalvarsan, mapharsen, silver-arsphenamine and tryparsamide by intravenous injection, consists of measured glass syringes, measured glass irrigating cylinders, glass funnels, irrigating stands, rubber tubing, and needles of various sizes. The glassware should be boiled in distilled water or put through the autoclave, and it must

be remembered that all this glassware breaks easily by rough handling and too quick changes of temperature. Needles should be cleaned immediately after use by washing and passing the stylet or wire through them several times. They should be dried by blowing ether through them, the stylet then inserted, and the needles put away in liquid petrolatum. They should be sharpened each time and should be sterilized by boiling for not over 10 minutes. In sharpening on the oilstone, the slope should be flat and rather short and the edges not rounded.

The rubber tubing should be of the best quality red rubber, and when new tubing is used it should be soaked for 24 hours in a 4.5 per cent sodium-hydroxide solution, washed and boiled in distilled water for 4 hours, and then washed and boiled again for 2 hours, and finally washed again. This is necessary because rubber contains compounds which cause dangerous reactions.

All of the arsenicals (salvarsan, neosalvarsan, mapharsen, silver-arsphenamine, sulfarsphenamine and tryparsamide), should always be kept with all the wrapping around them, and they should never be kept together. This is especially important with salvarsan and neosalvarsan, because to do so gives the danger of injecting into the veins an unneutralized salvarsan, which means death in nearly all cases. Each should be kept away from light and heat. Just before mixing, the tube should be taken out of the package, inspected, and put into 95 per cent alcohol to be sure it is not cracked. Never use a tube which is cracked or in which the powder is lumpy or discolored or which has an unusual odor when opened. The color of the different arsenicals is as follows:

Arsphenamine.—Pale yellow to a lemon yellow;
Neoarsphenamine.—Lemon yellow to canary yellow;
Mapharsen.—White;
Silver-arsphenamine.—Dark-brown;
Tryparsamide.—White;
Sulfarsphenamine.—Light yellow cast.

Always note and record the name of product, maker, lot number, and dosage used, and the name of the patient to whom it is given.

The water for intravenous use should be distilled always and never more than 24 hours before use. It should be sterilized not more than 24 hours before use. The same thing applies to physiological salt solution, of course. Salvarsan must be alkalinized before used. For this purpose 0.85 cc of 4 per cent freshly prepared sodium-hydroxide solution is used for each 0.1 Gm. of arsephenamine. This is the correct amount necessary to form the disodium salt of arsphenamine, the form which is best tolerated by the patient. The preparation of these drugs for administration is so important that it should be made by, or under, the direct supervision of a medical officer. The following principles should be kept in mind: Salvarsan is permitted to stand for 30 minutes after preparation prior to administration. The solution may stand as long as 3 hours, without undergoing any increase in toxicity, provided it is protected from the air, not shaken, and the temperature does not exceed 30° C. Mapharsen is relatively stable and may be given as long as 1 hour after preparation. All of the other arsenicals should be administered as soon as prepared and never longer than 20 minutes after preparation. All of these drugs should be given slowly except mapharsen which, in contradistinction to the others, should be given rapidly. All of these arsenicals are given intravenously except sulfarsphenamine which is injected intramuscularly. No salvarsan or neosalvarsan should be given without resting and fasting before and after for several hours.

Always have convenient and ready, syringes and needles, with ephedrine hydrochloride and ampules of sodium thiosulfate, in case of bad reactions.

Mercury is occasionally given by mouth in the form of mixed treatment: (Bichloride of Mercury, 1 grain; Potassium Iodide, 2 drams; water or other vehicle, 3 fluidounces;) 1 teaspoonful three times a day; or mercury with chalk, 1 grain, three times a day. The best method is probably by inunction of about 4 Gm. of strong mercurial ointment once daily on a different part of the nonhairy portion of the body, using the inner side of the thighs, inner side of arms, and between hip and arm pits, never using one place the second time until all the other places have been used. The salicylate of mercury, 1 grain in 1 cc of liquid petrolatum, or the succinimide, one-sixth grain in 1 cc of water, are on rare occasions given intramuscularly. Bismuth should be administered only by intramuscular injection and the subsalicylate is probably the best form. The dose is 0.2 Gm. of subsalicylate (not 0.2 Gm. of metallic bismuth), at 5 to 7 day intervals. A course is 6 to not more than 12 injections. The solutions of mercury and bismuth for intramuscular injection, should be shaken up to the last second, as they tend to settle out quickly. In injections into the buttock always draw back the plunger of the syringe to see if any blood shows, which indicates the needle is in a vein, before injecting. If blood shows, pull the needle out and reinsert. Inject slowly.

Of the urinary system.

For the most part this is done through the urethra and through the ureters with instruments called catheters, sounds, bougies, filiforms, cystoscopes, urethroscopes, urethral dilators, and urethrotomes.

The first consideration is the care of these instruments. Some of them are rubber, some woven silk with wax covering, some silver, some steel or brass with silver or nickel plating, some whalebone, and some with glass lenses or prisms cemented in them. All should be handled carefully and not scratched, bent, or dented. Metal instruments should be kept clean and dry and polished with nonscratching material, and well greased with vaseline when in moist climates, as on shipboard. All metal instruments except cystoscopes may be boiled for not more than 10 minutes in distilled water. Rubber and whalebone catheters may be boiled for not more than 10 minutes.

The woven, wax-covered instruments as well as the cystoscopes should never be boiled, but should be sterilized by thorough washing in soap and water and soaking for at least 20 minutes in formaldehyde or oxcyanide of mercury solution.

The metal instruments must never be soaked in bichloride of mercury solution. Alcohol and phenol solutions tend to injure rubber or wax.

The sizes of instruments to be passed into the urethra or on into the bladder or by the ureters up to the kidneys are indicated by three different systems of numbering—French, English, and American. For practical purposes the French only should be considered. These have a scientific basis and the number indicates the number of millimeters (a millimeter is one twenty-fifth of an inch) around the instrument. Thus, a No. 25 sound would be exactly 1 inch in circumference. The instruments are usually made only in even sizes from 10 to 32, inclusive, and in both odd and even sizes from 4 to 10. The latter are used almost exclusively in ureteral work.

For urethral or ureteral catheterization the patient should lie on his back in an easy position and breathe with the mouth open and the belly muscles relaxed. In cystoscopic and urethroscopic work the patient lies on the back with the knees and thighs flexed and supported, and the operator stands

between the legs. The whole penis should be cleansed with soap and water and bichloride of mercury solution, or, better, with full-strength alcohol; although the latter may sting a little, it is perfectly safe.

No instruments should be passed into the urethra without a lubricant. A tragacanth or similar jelly should be used for cystoscopes and routine work where the treatment is with watery solutions. (*See* formula on p. 240.) Glycerin is also a fairly good lubricant. However, sterile liquid petrolatum should always be used for difficult catheterizations and the passing of sounds. The oil is warmed and slowly injected with a syringe held tightly against the meatus.

In cystoscopic work and where difficulty is expected it is a great advantage to give a hypodermic injection of morphine ¼ and atropine $\frac{1}{150}$ grain about three-quarters of an hour before and to inject vigorously a syringeful of 4 per cent procaine or novocaine solution 5 minutes before and repeated just before starting.

Gentleness is of the greatest importance in passing instruments in the male urethra. Rough handling or overdilation will often give fever and chills, which reaction is known as a urethral chill. Men have been killed by rough instrumentation.

For the inexperienced the best catheter to try in a difficult case is a woven, waxed one. Start with a No. 20, and then a No. 16, and then a No. 12, and finally a No. 10. It will follow the curve of the urethra better if it is warmed to a little above body temperature. In ordinary cases a No. 20 rubber catheter passes easily. The penis should always be put on a stretch. In cystoscopic work in America an irrigating outfit with sterile water or boric acid solution is used at room temperature.

After use all instruments should be thoroughly rinsed off and sterilized in the appropriate way. After cystoscopic study and difficult instrumentation a patient should always lie down for a few hours and drink plenty of water, as pains, chills, and fever often follow in these cases.

If a man cannot urinate and has a great deal of urine in the bladder and a catheter is successfully passed, do not draw off more than 600 cc at first. Leave the catheter in place and fix it with adhesive strips and then clamp the catheter with a hæmostat and let out about 150 cc per hour until the bladder is empty. This will lessen the shock that accompanies emptying an overstretched bladder.

Sometimes a man can be made to urinate naturally by some of the following means: Applying a hot towel to the pubis; immersing the penis in warm water; letting water run in his hearing; leaving him alone for a while; letting him sit in a tub of hot water; giving a good warm enema; and giving plenty of water to drink.

DOSES, DANGERS, AND STRENGTHS OF SOLUTIONS USED IN GENITOURINARY AND VENEREAL TREATMENT

1. *Argyrol (mild protein silver).*—Used in solutions of 5 to 10 per cent as an injection.

2. *Alum.*—Sometimes used in the treatment of chancroids. It is dried, pulverized, and sprinkled on the ulcer. There is no danger, but it may sting very sharply.

3. *Bismuth subsalicylate.*—This is given in doses of 1 or 2 cc of the subsalicylate, each cc representing 0.13 Gm. of metallic bismuth suspended in sterile olive or peanut oil. Care must be taken in the administration to be sure the needle is not in a vein or artery. This substance injected into a vein

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is apt to be fatal. If injected into an artery it may produce necrosis of the structures supplied by the vessel.

4. *Camphor.*—Given in doses of 0.065 Gm. (1 grain) in cases of irritation of the neck of the bladder. There is no danger in this dosage.

5. *Copper sulfate.*—Used in the form of crystals or in solutions of 10 to 25 per cent strength for application to ulcers. It is painful and should be preceded by procaine locally. There is no danger, but if it should be swallowed, milk should be given and the stomach lavaged.

6. *Formaldehyde.*—Used in full strength to touch up ulcers. To sterilize instruments soak them in 5 to 10 per cent solution for 20 minutes and always rinse off with sterile water before using. If accidentally swallowed, give milk and wash out stomach.

7. *Iodides.*—These are given in the form of sodium or potassium iodide in saturated solutions when 1 drop equals approximately 1 grain. The dose is from 5 drops to 100 drops by mouth. The danger is very little and the signs of toxicity are headache, watering of eyes and nose, and breaking out in small boils. Sodium iodide is also given intravenously in a 10 per cent solution; dosage from 20 to 100 cc. A slight burning of the throat sometimes occurs when given in this way.

8. *Mapharsen.*—Always given intravenously in sterile water so that each 0.01 Gm. of the drug is represented by about 2 cc of water. The dose is not more than 0.06 gram.

9. *Mercurochrome.*—One per cent for urethral and bladder injections and also for intravenous use, 10 cc and even 25 cc being given in desperate cases. Should be freshly made. Ten per cent strength is used for touching ulcers.

10. *Mercurial ointment, strong.*—Used as an inunction in treating syphilis; should be diluted with equal parts of vaseline or lanolin. Rub a piece weighing 4 Gm. into the skin on a nonhairy portion of the body at night and wipe off with kerosene in the morning. Change the spot rubbed every night.

11. *Mercurous chloride mild, ointment of* (*calomel ointment*).—One-third strength made up in lanolin for venereal prophylaxis.

12. *Mercury bichloride* (*bichloride of mercury*).—Used in a strength of 1–1,000 for sterilizing the skin, nonmetallic instruments, etc. Used by mouth in the treatment of syphilis, in solution so that a dram dose equals one-thirty second to one-twelfth grain. Rarely given by intramuscular injections.

13. *Mercury oxycyanide.*—One to 1,000 solution for soaking instruments. Noncorrosive and metal instruments are not harmed.

14. *Mercury protoiodide.*—One-sixth to one-third grain tablet three times a day in the treatment of syphilis.

15. *Mercury salicylate.*—One grain in 1 cc of liquid petrolatum injected deep into the buttock once a week in treating syphilis.

16. *Mercury succinimide.*—Two-fifths to three-fifths grain in 1 to 3 cc of water injected about once a week deep into the buttock in treating syphilis.

The dangers of mercury when absorbing too much in medication are ptyalism or salivation (sore teeth and excessive secretion of saliva) and irritation of the kidneys. Stop at once and give a mild purge of magnesium sulfate. The emergency treatment in cases of accidental swallowing of mercury should be borne in mind always.

17. *Methenamine.*—Given by mouth in dosages of 0.3 to 1 Gm. about four times a day for neutralizing irritating urine. Should be combined with sodium acid phosphate, as the urine must be acid for it to be of value. The sign of

excessive dosage is irritation and a slight smokiness of the urine. It should be stopped at once.

18. *Neosalvarsan.*—Always give intravenously in sterile water so that each 0.1 Gm. of the drug is represented by about 2 cc of water. The dose is from 0.3 to 0.6 Gm. and it requires no neutralization.

19. *Phenol.*—Used in full strength to touch ulcers. Sometimes in weak solutions of 1–100 to 1–200 as a dressing; also to sterilize instruments. When used in too large a dressing enough may be absorbed by the skin to produce irritation of the kidneys, the sign of which is smoky urine. In accidents where strong phenol is spilled on the skin use alcohol locally. Where it has been swallowed use magnesium sulfate solution and wash out the stomach.

20. *Potassium acetate.*—Used by mouth in dosages of 2 to 4 Gm., in irritation of the bladder.

21. *Potassium citrate.*—Used by mouth in dosages of 1 to 1.5 Gm., in irritation of the bladder.

22. *Potassium permanganate.*—Used for injections and bladder irrigations. Start with a solution strength of between 1–10,000 and 1–8,000 and increase the strength cautiously.

23. *Procaine* and *novocaine.*—Used in ½ to 1 per cent solutions for local anæsthesia. To inject in the urethra, a 4 per cent solution is used. There is practically no danger in these strengths.

24. *Protargol* (*strong protein silver*).—Used in strengths of ½ to 1 per cent as an injection. The silver solutions should be fresh and they should be kept away from light. There is little danger in the strengths noted. To neutralize where irritation results or where swallowed accidentally give saturated solution of table salt and wash out the stomach.

25. *Salvarsan.*—Always give intravenously in solution so that each 30 cc equals 0.1 Gm. Always neutralize with sodium hydroxide because it is acid. The doses are from 0.2 to 0.4 Gm.

26. *Silver nitrate.*—Used in the form of sticks to touch ulcers or in 25 to 50 per cent solution for the same purpose. It may be used in solution for urethral injection or into the bladder but should not be used stronger than 1–10,000 to 1–5,000 solution at first. Its action is neutralized by salt solution.

27. *Silver-arsphenamine.*—Always given intravenously in sterile water or physiological salt solution so that each 0.1 Gm. of the drug is represented by about 7 cc of water. The dose is 0.3 Gm. or less.

28. *Sulfarsphenamine.*—Always given deep into the muscles of the buttock, in the smallest amount of water in which it will dissolve. The dose is from 0.2 to 0.4 Gm. and this will dissolve in about 1 cc of water.

29. *Silvol.*—Same as argyrol.

30. *Sodium acid phosphate.*—In dosages of 0.5 Gm., to acidify the urine. Usually combined with methenamine in the dosage of 0.5 Gm. each.

31. *Sodium thiosulfate.*—One gram in 10 cc of water intravenously for mercury, bismuth, arsenic (salvarsan and neosalvarsan), silver, and lead poisoning. One gram in 10 cc of cold (never boil the solution) sterile water.

32. *Sulfanilamide.*—Of value in many infections. It is given by mouth in doses of 20 to 120 grains a day. Due to idiosyncracies to the drug shown by many patients, it should never be given unless the patient is under medical supervision.

33. *Tincture of hyoscyamus.*—Given in irritation of the urinary tract in dosages of 10 to 15 drops.

34. *Tryparsamide.*—Given in 3 Gm. doses in 10 cc of water intravenously.

NOMENCLATURE OF TERMS RELATING TO THE ANATOMY, DISEASES, INJURIES, CONDITIONS, AND INSTRUMENTATION OF THE MALE GENITOURINARY SYSTEM

Adenopathy.—Enlargement of lymphatic glands.

Alopecia.—Natural or abnormal deficiency of hair.

Balanitis.—Inflammation of the glans penis (head of the penis).

Balanoposthitis.—Inflammation of the glans penis and the prepuce (foreskin).

Bougie.—A slender sound with a bulb-shaped tip.

Bubo.—Inflammatory swelling of a lymphatic gland, particularly in the axilla or groin.

Castration.—Complete removal of the testes.

Catheter.—A tubular instrument used to draw urine from the bladder or kidney.

Chancre.—The primary lesion of syphilis no matter where it appears. The word is from the Greek and literally means "a crab," but its general meaning now is an ulcer. The word "cancer" is also from the same Greek word.

Chancroid.—A soft, nonsyphilitic sore. Also called "soft chancre."

Chordee.—Inflammation of the corpus spongiosum of the penis resulting in a painful semierection and bending downward of the penis.

Clap.—Same as gonorrhœa.

Condyloma.—A wart-like excrescence near the anus or vulva, especially the flat, moist papule of secondary syphilis.

Corona.—The crown-like rim surrounding the base of the glans penis.

Cystitis.—Inflammation of the urinary bladder.

Cystoscope.—An electrically-lighted instrument for examining the interior of the bladder.

Dermatitis exfoliativa.—A severe, obstinate, scaly rash sometimes resulting from poisoning by arsenicals used in treating syphilis and usually associated with loss of the hair and nails.

Ejaculation.—The sudden expulsion of the seminal fluid.

Epididymis.—Oblong, convoluted body attached to each testicle.

Epididymitis.—Inflammation of the epididymis.

Epispadias.—A congential malformation in which the urethra opens on top of the penis.

Erection.—The condition of being made rigid and elevated.

Eroding.—Eating away; destroying.

Filiform.—Thread shaped; an extremely slender bougie.

Frænum.—The fold on the lower surface of the glans penis by which it is attached to the prepuce.

Glans.—The head, or terminal end, of the penis.

Gleet.—An old, chronic form of gonorrhœal discharge.

Gonococcus.—The same as Neisseria gonorrhœæ.

Gumma.—A soft, tumor-like swelling occurring in the third stage of syphilis.

Hæmatocele.—Effusion of blood into a cavity, especially into the ones containing the testes.

Hermaphrodite.—An individual who partakes or appears to partake of both male and female characteristics.

Hydrocele.—A collection of excess serous fluid in the sacs containing the testes.

Hypospadias.—A congential malformation in which the urethra opens on the under side of the penis.

Inguinal rings.—Openings in the wall of the abdomen through which the spermatic cord passes; known as internal and external.

Iodism.—A condition resulting from prolonged administration of iodides characterized by headaches, running nose, watering eyes, and skin eruptions.

Kohlman dilator.—An instrument passed into the urethra and then made to expand, thereby stretching strictures.

Locomotor ataxia (tabes dorsalis).—A degenerative condition of the spinal cord resulting from syphilis that produces difficulty in walking, etc.

Meatus or *meatus urinarius.*—The external opening of the urethra.

Mucous patches.—Syphilitic lesions or sores in the mouth and about the genitalia and anus, usually occurring in the secondary stage.

Orchitis.—Inflammation of the testicle.

Paraphimosis.—The retraction of a narrow or inflamed foreskin behind the glans penis which cannot be replaced.

Paresis, or *general paresis.*—A chronic, degenerative disease of the brain resulting from syphilitic infection and causing insanity.

Penis.—The male organ of copulation or sexual intercourse.

Perineum.—The space between the anus and genital organs forming the floor of the outlet of the pelvis and occupied by the terminations of the rectum, the urethra, and the root of the penis, the vagina in the female, and various muscles, fasciæ, vessels, and nerves.

Phagedenic.—Same as eroding.

Phimosis.—Tightness of the foreskin so that it cannot be drawn back over the glans penis.

Posthitis.—Inflammation of the foreskin.

Prepuce.—The foreskin.

Prerenal.—In front of the kidney.

Prostate or *prostate gland.*—A gland surrounding the neck of the bladder and the urethra and in which the secretion of the testes is diluted.

Prostatitis.—Inflammation of the prostate.

Ptyalism.—Excessive secretion and discharge of saliva, especially from the administration of too much mercury.

Pubis.—The bony arch above the root of the penis.

Pyelitis.—Inflammation of the pelvis of the kidney.

Pyelonephritis.—Inflammation of the pelvis of the kidney with kidney involvement.

Pyonephrosis.—A condition in which pus is present in the pelvis of the kidney.

Raphe or *raphe scroti.*—The seam or ridge in the middle of the scrotum.

Resectoscope.—An instrument for resecting a portion of the prostate through the urethra.

Rugæ.—The folds or wrinkles of the scrotum.

Salivation.—Same as ptyalism.

Scrotum.—The sac or pouch which contains the testes.

Secondaries.—The symptoms of the secondary stage of syphilis.

Semen.—The secretion containing the spermatozoa produced by the male generative organs ejaculated during coition.

Seminal vesicles.—Two small sacs situated at the base of the bladder serving as reservoirs for the storage of semen.

Seminal vesiculitis.—Inflammation of the seminal vesicles.

Sound.—An instrument used to measure the size of or to dilate the urethra or ureters.

Spermatic cord.—The cord-like structure containing arteries, veins, lymphatics, and the vas deferens or ductus deferens, that suspends the testicle.

Stricture.—An abnormal narrowing of a canal, duct, or passage.

Sulcus.—A groove, trench, or furrow; the sulcus behind the glans penis.

Tertiaries.—The symptoms of the third stage of syphilis.

Testicle.—The male organ producing the spermatozoa.

Treponema pallidum.—The microörganism causing syphilis.

Ureter.—The tube which conveys urine from the kidney to the bladder.

Ureteritis.—Inflammation of the ureter.

Urethra.—The membranous canal or tube through which urine passes from the bladder to the external air. In the male it also conveys the seminal ejaculations.

Urethritis.—Inflammation of the urethra.

Urethroscope.—An instrument used for examining the interior of the urethra.

Urethrotome.—An instrument used to cut strictures of the urethra.

Varicocele.—Enlargement of the veins in the spermatic cord.

Vas deferens or *ductus deferens.*—The excretory duct of the testicle and carrying the spermatozoa from the testes to the seminal vesicles.

Section 4.—THE PREVENTION OF VENEREAL DISEASES

Because of their prevalence, ready transmissibility, and far-reaching effects, the venereal diseases are a menace to home and to family life. In one way, and one only, can infection with venereal disease be prevented, and that is by completely avoiding promiscuous sexual intercourse. Clean living, the indulgence in athletic sports which promote health and occupy the mind, and the avoidance of alcohol during hours of relaxation are important factors in the prevention of venereal disease.

The principles underlying the control of veneral diseases differ in no way from those concerning the prevention of other communicable diseases. The

immediate, practical problem is to prevent the further spread of venereal infection.

The preventive measures for venereal diseases may be summed up as follows:

A. Control through the community.
   1. Segregation and regulation of prostitution.
   2. Suppression of clandestine and occasional prostitution.
   3. Isolation and/or treatment to shorten the period of infectivity.
   4. Suppression of questionable resorts.

B. Control through the individual.
   1. Social approach—disuasive measures.
      a. Ethical and moral instruction.
      b. Instruction in effects of disease on individual and on his social relationship.
   2. Recreational approach—substitutional measures.
      a. Occupation to engage interest, fill leisure, absorb energies, and proper social contacts.
   3. Disciplinary approach.
      a. Preventing exposure by restriction of liberty.
      b. Placing localities out of bounds.
      c. Denial of liberty to disease carriers.
      d. Segregation and treatment of infected persons.
      e. Penalties for disabilities of venereal origin.
      f. Punishment for failure to use prophylaxis.
   4. Personal prophylaxis.
      a. Mechanical appliances.
      b. Medicinal agents
         —at disinfecting stations.
         —in portable form.

The use of both chemical and mechanical prophylactics against venereal infection has been advocated in the Navy for many years. The effectiveness is high when these measures have been used early and properly. Those who expose themselves to the danger of contracting a venereal disease should be urged to use immediate prophylaxis.

On January 9, 1909, the Secretary of the Navy issued an order to the service which required promulgation of information regarding venereal disease to the men of the service, and directed that facilities for prophylaxis be made available. Since 1914 personnel of the Marine Corps, and since 1916, personnel of the Navy and Marine Corps, have been penalized by losing their pay and time while absent from duty because of a venereal disease, which was contracted as a result of their own misconduct.

The oldest and best prophylactic measure is the mechanical appliance known as the sheath or condom. This is usually made of rubber and is for sale in most Ship's Service Stores. Government regulations specify high requirements of rubber prophylactics and shoddy materials are not sold by reliable firms.

Two simple tests that can be applied to rubber goods sold by Ship's Service Stores are quoted from the Bureau of Standards specifications:

"E–3. Inflation test.—The prophylactics shall withstand inflation to a length of 24 inches for a period of 1 minute, and when inflated shall show no porosity or thin spots.

"E–4. Oil test.—One hour after application of mineral oil of medicinal grade the prophylactics shall withstand inflation to a diameter of 6 inches for a period of 1 minute. It is not essential that the shape of inflation be uniform."

In the use of a condom it is essential that some space remain at the end to prevent any chance of undue stress or strain on the rubber. Upon removal care must be exercised so as not to increase the chance of contamination from the sheath. Then immediate washing of the penis and surrounding parts and the proper application of the contents of a prophylactic tube or 33 per cent calomel ointment will prevent many a case of venereal infection. Prophylactic tubes, often called Sanitubes, are given to anyone on request at the sick bay, dispensary, or prophylaxis station.

Medicinal or chemical prophylactic treatment used immediately or within the first hour after exposure is very efficacious in preventing the development of venereal infection. Although its value rapidly diminishes from then on and is greatly reduced after 8 hours have elapsed, men returning to the ship or station within 8 hours following exposure should be urged to avail themselves of chemical prophylaxis under supervision of a hospital corpsman.

A careful record should be kept showing the name and rating of the person treated, the hour of treatment, the hour and place of exposure, and the name and address of consort.

The method of prophylaxis used in most Navy prophylaxis stations is to have the man urinate and then thoroughly wash the penis, scrotum, and pubic region with liquid soap and warm water. One-half a syringeful of 1 per cent solution of strong protein silver (protargol) or 10 per cent solution of mild protein silver (argyrol, silvol) is injected gently into the anterior urethra and allowed to flow out; the remainder is then injected and held in the urethra for 5 minutes. When the parts that were washed have thoroughly dried, the penis, scrotum, thighs, and pubic region are liberally annointed with 33 per cent calomel ointment in lanolin. The ointment should be well rubbed in for at least 10 minutes, paying especial attention to the corona and region of the frænum. The clothing should be protected with a temporary dressing and the ointment allowed to remain for 12 hours.

The Navy prophylactic tube consists of a pliable, metal tube with a tip which can be inserted into the urethra. One half of the contents is injected into the urethra and the other half is used externally. Use of the contents immediately before cohabitation is a valuable preventive measure. The formula of the contents of the Navy prophylactic tube is as follows:

Mild mercurous chloride (calomel)	33
Camphor	2
Phenol	3
Anhydrous lanolin	39
Benzoinated lard	20
Beeswax	3

Each tube contains 7.5 grams of this ointment.

As a result of a 4-year investigation undertaken at the U. S. Naval Medical School, Washington, D. C., to compare the efficacy and suitability of the many substances considered of possible value in the immediate chemical prophylaxis of venereal infection there has been reported a formula that will probably prove to be superior to and more effective than any previously used.

The value of the various prophylactic measures in preventing venereal infection is well shown by the reduction in the total admission rate for syphilis, gonococcal, and chancroidal infections from 193.52 per 1,000 in 1909 to 63.90 per 1,000 in 1937. During this same period the admission rate per 1,000 for gonococcal infections was reduced from 102.51 to 43.85, for chancroidal infections from 27.51 to 7.82, and for syphlitic infections from 25.81 to 11.08.

It should always be remembered that diseases that have attacked more than half the men of the country during youth, diseases that bring misery to thousands of children and suffering to hundreds of thousands of women innocently infected, and that are incurred almost exclusively through promiscuous sexual intercourse, are diseases to be avoided. It should also be remembered that the man who practices promiscuous cohabitation almost invariably contracts one of the venereal diseases, sooner or later, in spite of every precaution. And if sufficient moral stamina to resist sexual temptation is not possessed, then it must be remembered to take prophylactic treatment as soon as possible after exposure.

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Section 5.—INDUSTRIAL MEDICINE AND INDUSTRIAL HAZARDS

Industrial Medicine is that branch of medicine which deals with the prevention of diseases and injuries among industrial workers. Strictly speaking, industrial medicine has become of such importance in late years, that it is not now limited to workers, but endeavors to promote good health and increase the life span of the entire people.

Its purposes or aims are to insure good health, the prevention of avoidable accidents, to alleviate unnecessary suffering and thereby provide contentment and promote more efficient work. It further deals with the rehabilitation of diseased and injured persons and reclassifies them to work in such positions as their disabilities will permit, thereby obviating the necessity for their becoming public charges and insuring them a livelihood.

Industrial Medicine is akin to Hygiene and Sanitation and Preventive Medicine, but spreads out to embrace accident prevention as well. Its aims are accomplished by endeavoring to reduce the health and accident hazards to a minimum by education, safety devices and precautions, periodic physical examinations, cooperation of employees, and by the passage of laws for the protection of the workers.

The need for the development of this branch of Medicine is apparent to all, when it is known that in the sixteenth century the average life expectancy of the working man was 22 years, as compared to 44 years for those of the upper classes. The working men were really slaves. They worked from 12 to 20 hours daily, 7 days a week. They were subjected to forms of health hazards about which little or nothing was known. The death of the men was considered a natural course of events.

The value of Industrial Medicine to the workers has been clearly manifest. Today, the average working man in industry may well expect to live to the age of 50 with still a better outlook for the future when the hazards to health and accident are better understood and safety measures are developed and perfected to protect against such hazards.

In this country today, every employee is protected by laws which require that certain standards of protection be maintained against health and accident hazards. Compensation laws are in force to require the payment of disability benefits to those incapacitated by accident or disease which were connected with their employment.

A National Safety Council was established in 1912 and its slogan of "Safety First" has become a by-word in all homes. In 1914 a health section composed largely of Industrial Surgeons, was incorporated as part of the association. Thus the need of medical advice in industry was established. It is a well-recognized fact that the "human machine" constitutes a very definite hazard to health and accident. The medical man therefore must form a definite part of any industrial organization. Today, the National Safety Council in America is one of the greatest organizations of its kind and by its help has put the working conditions in this country on a very high plane and the industrial worker has reaped the benefits.

Today, every industry in this country, no matter how large or how small, has its medical staff, or its equivalent. Many large industries have their own hospitals and medical staffs; others have contract surgeons but all are required in one form or other to give medical attention to the employees under them. The Government having passed such laws must therefore lead the way in protecting its own employees. The United States Navy is one of the largest of the industries maintained by this Government. An organization has been set up in the Navy to protect its personnel, both civilian and naval. A safety engineer is provided, who acts directly under the Assistant Secretary of the Navy. He has supervision of the safety precautions taken to protect the civilian employees in the navy yards, ammunition depots, torpedo stations and the like. He is also a consultant in all matters pertaining to safety aboard ships, at training stations and other Navy Department activities. A naval medical officer is assigned to his office for the purpose of consultation in all matters pertaining to health and safety and to cooperate in devising means by which health may be protected and accidents prevented. Aside from this particular medical officer, all medical officers, dental officers, members of the Hospital Corps and nurses form the balance of the medical staff of this organization. It is essential that each one of these members know and understand the hazards to be encountered in the Navy, the steps to be taken to protect against injury and disease, the treatment of diseases and injuries arising therefrom and the organization of the medical personnel for such purposes. Naval medical personnel are required to perform duties ashore, at sea, in foreign countries, in the air and under the sea. In each of these places a variety of health hazards exist. It is therefore necessary that this personnel have a thorough knowledge of the industry to which they are attached, the hazards presented, the methods of prevention and the treatment of all injuries occurring.

An **occupational hazard** is any condition, existing in the trades, which will lead directly or indirectly to disease or injury. No method can be devised for classifying hazards for they are too numerous. However, they may be grouped under the following headings:

1. Those hazards present in the working force by reason of physical defect.
2. Those hazards found in the working places, including hygienic and sanitary defects, mechanical defects of machinery, lack of safety education and the like.
3. Those hazards presented by carelessness of employees. A large majority of accidents are due to this cause alone.
4. Those hazards due to unforeseen influences such as lightning, earthquake, tornado, and the like.

Industrial accidents may be prevented by an understanding of the hazards presented in the foregoing groups, by:

1. Thorough physical examination of all new employees, prior to their actual employment, to discover potential physical defects which would render the em-

ployee a hazard to himself or others. An example of this would be a person with manifestly defective vision being employed as a machinist. Physical examination of all regular employees periodically, to determine their ability to continue working at their trade and to reclassify them to less hazardous work or to retire them, as found necessary in individual cases. Repeated examination of all employees engaged in hazardous trades such as sandblasting, painting, chrome plating, T. N. T. handling, and others, to determine any possible systemic effects present as a result of their trade.

2. A constant and thorough inspection of all shops and working places by the safety engineer, the medical officer, and their assistants to determine the causes of accidents, the hazards to health and the immediate correction of these faults. Education of the employees by means of lectures, motion pictures, posters, and such, will further accomplish much in the line of prevention.

3. The prevention of carelessness by indoctrination of all employees with the spirit of prevention and building up a spirit of cooperation and high morale among them. If necessary, disciplinary measures should be taken when workers are habitually careless.

4. Providing, in so far as is possible, means of protection and escape in cases of disaster.

An exact classification of occupational diseases is difficult, in view of the great number and types of diseases presented by the industry. There is such a great variety and number of skin diseases in the trades that they are generally grouped under the heading of *Occupational* or *Trade Dermatoses.* It is sufficient to state here that practically all diseases and injuries may be associated with industry.

To successfully carry out the objects of Industrial Medicine the medical personnel of the Navy must know:

1. The organization of a safety unit of an industry and the duties of each of the personnel.

2. The hazards to health and accident presented by the particular industry to which they are attached.

3. The methods and means of protection to be established against the encountered hazards.

4. The treatment of industrial diseases and injuries.

5. The laws relating to compensation and treatment of sick and injured personnel, including a knowledge of the necessary reports and returns to be submitted in such cases.

For the purpose for which this book is intended, it seems sufficient to give the hospital corpsmen a general idea of the organization, hazards, protection, treatment and laws as related to the Navy, rather than to try to discuss Industrial Medicine as a whole. This may well be done by discussing the safety organization and its associated duties at a navy yard, for those in force at navy yards are applicable to a greater or lesser degree throughout the Navy. These will be considered in the order given.

Organization.

At all navy yards, the Commandant is the head of the organization. He is responsible to the Navy Department for the protection of the employees, as well as the naval personnel, under his command. He is familiar with the nature of the work being performed by the employees at his station and the health and accident hazards presented. Accordingly, he appoints, as the working head of the organization, a safety officer or a safety engineer, as he is better known. The safety engineer must be of sufficient rank and service to have

become familiar with the various trades in a navy yard, a knowledge of machinery, a man of cooperative ability and well liked, and having sufficient knowledge of safety devices and appliances to intelligently make inspections and recommend proper protective measures. His duties are primarily, to prevent accidents and promote healthy working conditions. It is his duty to inspect all working places, make a general survey of all mechanical conditions and to recommend the addition of all necessary safety appliances for the protection of the workers. He must make daily inspections of the shops to see that these safeguards are in working order and are being used. He must investigate all major accidents in order to determine the cause and recommend methods to prevent a similar accident. There should be full cooperation between him and the medical officer. All improvements come under his supervision.

The Commandant further assigns a medical officer to act as advisor to the safety engineer. The medical officer must be of the same qualifications as the safety engineer, with the addition that he must be thoroughly versed in the diseases connected with Industry. He need not have a thorough knowledge of machinery but must understand sufficient of the operation of the various machines to intelligently advise the safety engineer in matters relating to the development of safety devices. The duties of the medical officer are as follows, and in this connection it is well for members of the Hospital Corps to understand the nature of these duties in order that they may be of assistance to him in the performance of these duties:

The medical officer is the safety engineer of the human body. He acts as consultant to the safety engineer in all matters pertaining to the general welfare and health of the employees. Hygiene and sanitation are his important duties. He must interest himself in the employees and instruct them in the every day principles of personal hygiene and self preservation. He must instruct the employees in safety measures and encourage them to cooperate in protective measures. They must be made "safety conscious" or "safety minded". The morale must be kept up. A high morale leads to fewer accidents and better workmanship. The medical officer must inspect all working places in order to have a better understanding as to the actual conditions under which the men work. He must make appropriate recommendations to improve deficiencies noted and must then see that these recommendations are carried out. He must personally make all physical examinations of prospective employees or see that the physical standards for employment are adhered to. He must make physical examinations of all employees believed to be physically unfit for further work to prevent them from injuring themselves or others. He must further treat and view the scene of all accidents to be able to determine their cause and to assist the safety engineer in formulating plans to prevent recurrences. He must so organize the personnel under him that prevention will be effectively handled.

The safety engineer is assisted in his work by the foremen of the shops and in some instances by safety committees in each shop elected by the employees. These men or committees are generally chosen from among the older employees and from men who have considerable experience in their trade. It has been repeatedly recommended, but not as yet accomplished, that the safety organization be enlarged by the creation of two new civil service ratings. These are, a civilian safety engineer and a civilian assistant safety engineer. These men would be appointed by competitive examination and should be men who have had considerable experience in the trades with a liberal understanding of all. They would act as assistants to the naval safety officer and would be of great value to the organization, inasmuch as their duties would be permanent. A

naval officer is subject to change of duty and cannot act as permanent safety officer. In changing the safety officers at intervals a weakness is left in the organization which the civilian assistants could well fill, until such time as the new officer became familiar enough with his new duties to take hold.

The organization of the medical advisor is composed of junior medical officers, dental officers, to some extent, members of the Hospital Corps, and of nurses. The duties of the hospital corpsmen are to assist the medical officer in his inspections, assist in the treatment of the injured and to prepare the necessary reports and returns in cases of accident, occupational disease, and the physical examination of employees. This, then, is briefly the organization of a safety unit in a navy yard. This unit will function as well aboard a battleship or in other places. The commanding officer of a ship is the head of the organization. He is assisted by the First Lieutenant acting as safety engineer. Division Officers act as assistants to the First Lieutenant and safety committees are elected in each division from among the crew. The medical officer is the advisor to the safety engineer and he in turn is assisted by the dental officer and hospital corpsmen. All then that is necessary for the unit to function is that a study be made of the hazards presented aboard ship and to proceed as explained later.

Hazards to health and accidents.

The organization completed, a study must be made to determine the hazards existing in the particular organization to which the unit is attached. There are major hazards and minor hazards. A major hazard is represented by unguarded machinery or improperly or faulty insulated electrical wiring. A minor hazard is a greasy shop floor, loose articles lying around on the deck or an open, unguarded hatchway aboard ship. It must be remembered that no two industries present the same hazards. There are hazards peculiar to each trade or profession. Efforts must therefore be made by the safety organization to locate these hazards and afford protection accordingly. To indicate just what types of hazards may be encountered while working with a safety unit of a navy yard and in an effort to make the subject of hazards a little clearer to the readers the following questionnaire, prepared by the inspector of the Medical Department Activities of the West Coast is quoted in part. This questionnaire represents a very thorough picture of the major hazards with which a safety unit of a navy yard must cope, aside from the many minor ones always present in any organization. Answers to these questions must be made not only to the inspecting officer but they must in some form or other be answered daily if the organization is to be successful. By this is meant that problems of this nature are a daily occurrence and the safety unit must be prepared to meet them at once and not wait to formulate answers at inspection intervals.

"Q. 1. What industrial processes employ lead at some stage of the work? This includes tetraethyl lead. How many workers are exposed to lead? What precautions are taken to prevent damage to workers using lead? How frequently are workers using lead checked to determine possible absorption of this element?

"Q. 2. What industrial processes employ chromium at some stage of the work? What precautions are employed to safeguard workers from chromium poisoning?

"Q. 3. What processes create a possible dust hazard? What precautions are observed to prevent damage to workers exposed to dust? Are routine examinations made of the chests of workers exposed to dust? Are X-rays made to de-

termine the presence of silicosis in workers exposed to dust? Have cases of silicosis developed?

"Q. 4. What industrial processes produce fumes which may be a health hazard? How are these fumes controlled?

"Q. 5. What industrial processes produce carbon monoxide in possible dangerous concentrations? What industrial processes produce carbon dioxide in possible dangerous concentrations? Have any cases of poisoning from these sources occurred?

"Q. 6. What processes employ volatile solvents during some stage of the work? Are aniline compounds used? Has damage occurred from their use?

"Q. 7. Are organic wax compounds used? Has damage occurred?

"Q. 8. What precautions are exercised to prevent damage from pipe covering compounds? What asbestos hazards exist?

"Q. 9. What precautions are taken to prevent damage from glass wool?

"Q. 10. What radio-active compounds are used on the station and what precautions are used to prevent damage from this and luminous paints?"

These are but a few of the questions asked but they serve the purpose for which they were intended, i. e., to indicate just what is meant by a health hazard and ones which must be studied in Industrial Medicine.

Protection.

Having made a survey to determine the hazards presented in the organization to which one is attached, means of protection must be sought. This is done first by protecting against physical hazards by employing physically fit men. In the Government, the physical standards are set according to the employment and the hazards to be met with in each type of work. The U. S. Civil Service standards are as follows:

1. For employment in arduous duties. Must be physically sound and in good health, active and able bodied. Rating "A". For some positions e. g. divers, requirements are specially rigid. Rating "A plus".

2. For less arduous employment. Requiring sound general health but less physical strength, though for some employment special requirements exist, i. e. perfect color preception for brakemen and chauffeurs. Rating "B".

3. For lighter and usually sedentary employments. General good health but minor anatomical defects not interfering with efficient performance of work may be passed, i. e. a typist may be lame.

Next, having employed a healthy working force it is necessary to protect their health. Proper working places must be provided and maintained. Hygienic and sanitary conditions must be kept on a high plane. All moving parts of machinery must be guarded; goggles provided for workers required to use them; helmets and masks for sand blasters; proper ventilation for the chrome workers; masks for asbestos workers; protection for workers in X-ray and radium; protective gloves, shoes, and other garments for foundry workers, and other means of protection too numerous to mention here must be available and used.

Special physical examinations must be made of all sand blasters, asbestos handlers, those exposed to radium and its compounds, lead workers, those engaged in dusty or smoky trades, handlers of T. N. T. and other explosives, etc., to prevent the occurrence of the diseases associated with those trades from injuring the men.

As mentioned before, all workers who are sick for any length of time and whose efficiency has fallen off because of physical reasons must be examined and either retired or reclassified.

Treatment.

The treatment of industrial diseases and injuries is essentially that for any others. All accidents are treated according to the severity and locality. Men are not allowed to treat themselves for even minor accidents by reason of the dangers of infection and later incapacity. The treatment of diseases of occupation is a specialty in itself and need not be considered here.

Laws governing workers and accidents occurring during work.

The laws governing occupational diseases and injuries are quite numerous. It is therefore essential that a hospital corpsman be familiar with only those pertaining to Government employees. These, in general, are as follows:

All men injured or taken sick during the course of their employment are required to report to the dispensary for treatment. It makes no difference how trivial the accident or how minor the illness, he must still report. No first-aid boxes are allowed in any of the shops or offices. When a man reports, his injury or illness is investigated, treated, or otherwise disposed of. At the U. S. Navy Yard, Puget Sound, Wash., a form report of the case is prepared in quintuplicate, two copies of which are forwarded to the safety engineer, one copy is sent to the foreman of the shop or the supervisor of the office, one is given to the employee, and one placed in his file jacket. A separate file jacket is maintained for each employee who reports to the dispensary for treatment or for any other reason and is a permanent record which is kept during the entire time of employment. The information furnished on this report is as follows: Date; whether report is of injury or return to work; name; rating; pay number; shop; diagnosis; date and hour of injury; date and hour reported to dispensary; whether or not injury is due to employment; disposition (treated and returned to work, given time off, or transferred to naval hospital); name of medical officer treating case; and patient's statement regarding injury.

In addition to this form, a card-index form, U. S. Employees' Compensation Commission Form CA–19, is made out in each case. This form is started when the man reports and when final disposition of the case is made it is likewise filed in the man's jacket.

When an injured employee returns to his shop or office, or when the foreman or supervisor receives his copy of the form report, the foreman or supervisor immediately fills out U. S. E. C. C. Form CA–2, and forwards it to the injury officer, who, in turn, submits it to the dispensary for completion by the medical officer treating the case. The medical officer gets the data for this report from the forms previously described.

U. S. E. C. C. Form CA–3 is forwarded at the termination of total or partial disability of an employee, or upon his death.

U. S. E. C. C. Form CA–4 is a claim for disability allowance or compensation for injuries received which must be submitted by the employee within 60 days after the injury. This form must also be completed by the medical officer attending the case and once again the form report and U. S. E. C. C. Form CA–19 are of value.

U. S. E. C. C. Form CA–8 is similar to Form CA–4 but must be submitted on the first and sixteenth of each month by the employee, during the period of his disability.

When it becomes necessary for an injured employee to have hospital or other treatment not provided by a dispensary or local physician, U. S. E. C. C. Form CA–16 is made out and forwarded with the patient to the hospital or place where he is to receive such additional care.

Times arise when there is doubt as to the origin of the disability, i. e., whether or not the disability is occupational. In such cases U. S. E. C. C. Form CA–17 is substituted for Form CA–16. Whenever U. S. E. C. C. Forms CA–16 and CA–17 are made out they must be accompanied by U. S. E. C. C. Form CA–20.

U. S. E. C. C. Form CA–21, Discharge Report of Injury Case, is forwarded when an employee is discharged from treatment after having been incapacitated by reason of occupational injury or disease.

U. S. E. C. C. Form CA–32 is a report of hernia and must be submitted in all cases in which claim is made that a hernia was caused by employment.

Numerous other forms, such as public bills for payment for treatment, are used in handling these cases, but as they are accomplished by the injury officer they are not listed here.

Forms showing reports of all physical examinations of employees, including the special examinations previously mentioned, are also kept. These are routine however, and are easily learned when actually engaged in this work. Special forms for W. P. A., E. R. N., and P. W. A. workers are also provided.

In conclusion, it is well to state the qualifications expected of a hospital corpsman engaged in Industrial Medicine.

1. He should realize that his first duty is to the workman who is injured.
2. His personality should inspire confidence.
3. He should have a knowledge of first aid.
4. He should have a knowledge of an efficient medical record system and of statistical methods.
5. He should have a knowledge of sanitation, of working conditions, of occupational hazards and preventive measures.
6. He should possess a general knowledge of industrial relations, including employment, its methods and problems.
7. He should have a working knowledge of the workmen's compensation laws.
8. It would be well for all hospital corpsmen to obtain and read the publication Medical Service in Industry and Workmen's Compensation Laws, 1938, published by the American College of Surgeons as prepared by M. N. Newquist, A. B., B. Sc., M. D., to enhance their knowledge of this subject and thereby be of more value to the medical organization of the Navy for industrial medicine. This publication contains concise, complete statements of the problems of the industrial organization and is of value to all industries.

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Section 6.—FIELD SANITATION

Health is necessary in war, and cannot be replaced by anything else.—Napoleon

Introduction.

The activities of a medicomilitary organization tend to concentrate toward one primary objective, "*The conservation of physical efficiency for combat.*" The hospital corpsmen of the Navy serve ashore, as well as afloat, and in

addition to their duties pertaining to naval warfare must be prepared to serve as members of the medical department of a naval landing party or a Marine Corps expeditionary force; and, as such, require a knowledge of field conditions.

One of the prime requisites for victory is health, consequently field hygiene and sanitation is one of the most important subjects for military personnel.

The functions of a military medical organization may be roughly divided into (*a*) prevention of disease and (*b*) treatment of disease and injury. Prevention of disease is of such vast importance to military personnel that this function will be considered in this section.

Preventive medicine is not an exact science nor is it possible to obtain 100 per cent efficiency. However, if by careful attention to the minor details the sanitation officer is able to increase military efficiency from 96 per cent to 98 per cent, he has not gained a mere increase of 2 per cent as it may seem, but has effected a gain of 50 per cent—that is, the noneffective rate has been reduced from 4 per cent to 2 per cent. It is this little difference which sometimes may be the deciding factor between victory and defeat.

Tact and a certain amount of technical ability are necessary qualifications for a successful sanitarian. Sanitation is so closely interrelated with cleanliness that the major portion of the duty of a sanitation officer consists in the supervision of cleanliness.

The differences between field sanitation and sanitation of garrisons are marked.

1. Field sanitation is easier to institute. For example, the devices used for the disposal of waste are of simple construction, whereas the installation of a water-carriage sewerage system requires more expert engineering knowledge, takes longer to construct, and by reason of its permanent nature is more expensive.

2. Constant vigilance is required to maintain field sanitary devices in proper sanitary condition.

3. Field sanitary appliances are a potential menace, if not properly maintained.

In established garrison life, with water-carriage waste disposal, an adequate and potable water supply, permanent housing facilities, protective screening for insect control, and similar modern developments, the duties of the sanitation officer are comparatively simple and more or less routine. In the field, the conditions are such that the field sanitary devices require constant and painstaking personal supervision from both the line and the medical officers in order that there may not be a weak link in the chain of sanitary measures.

Barracks life may give comparatively little concern, but when taking the field, vigorous sanitary measures must be instituted and maintained and, if possible, improved from day to day.

The commanding officer of an organization is responsible for the health of his command and the enforcement of sanitary measures. The medical department acts in an advisory capacity. The medical officer is charged with the initiative in making necessary recommendations to the commanding officer tending to the promotion of health and prevention of disease. For instance, the medical officer should recommend the type, number, and regulation of sanitary devices, but the responsibility for the actual construction and the maintenance of the same in a sanitary condition rests with the respective unit commanders. Likewise the collecting company of the medical battalion exercises supervision over sanitation, but the latrines, urinals, incinerators, etc., should be constructed by a detail from other units.

Victory, success in a military endeavor, is intimately interrelated and dependent upon personnel losses; in fact, the wastage from diseases frequently assumes such magnitude as to cause military campaigns to terminate in disaster.

When a million men are placed in the field and decimation from disease is prevented, it is defying one of the biological principles that tends to prevent over-crowding of a species. The methods available to combat these fundamental biological principles are not complicated and may be classified and will be discussed as follows:

1. Proper food.
2. Potable water supply.
3. Hygiene of the march.
4. Conservancy—waste disposal.
5. Insect control—fly, mosquito, louse, etc.

FOOD

In war the supply of food is most important. The men attached to an organization on field duty are likely to be entirely dependent upon the military ration. Hence, it is important that the field ration be well balanced in fats, proteins, and carbohydrates and it must have the required vitamin content.

An extended discussion of the component parts of a well-balanced ration would be a departure from the subject of this section and, as such data may be found in chapter VIII of this book, only certain aspects of a military ration which are related to field conditions will be considered.

Caloric value of the military ration.—It has been found that a ration consisting of 3,700 calories is insufficient for troops in the front line. It has been experimentally proved that troops on a test march can maintain weight on a ration of 4,100 calories.

If troops must entrench after a day's hike, a total of 5,000 to 6,000 calories per day is required. It is often impractical for a soldier to assimilate such a large number of calories per day, and consequently, in time of war soldiers are allowed a greater amount of food (often at the expense of the civilian population) so that they may have a reserve supply of fat in the body to enable them to temporarily withstand the unusual expenditure of foot-pounds of energy. It is stated that 20 pounds of reserve fat in a man's body will supply 3,000 additional calories per day for a period of 30 days.

The following is the caloric value of the United States Army ration:

	Calories
1. Reserve (haversack ration)	2,825
2. Mobile	3,500
3. Normal	4,125
4. Special	4,850

The heat of hot drinks and hot food supply additional calories, 1 pint of hot tea adding 50 calories of direct heat to the body. Hence the stimulating effect of hot tea, coffee, soup, and broth after a long march.

A soldier at hard work requires 24 ounces of food, daily, exclusive of water, made up as follows:

	Ounces
Proteins	4
Carbohydrates	17
Fats	3

In terms of articles of food, the above is represented by the following field ration:

Beef	ounces	11	Sugar	ounces	2
Cheese	do	3	Jam	do	2
Bread	do	16	Sago	do	4
Potatoes	do	10	Milk	pint	½

The nitrogenous foods (proteins) serve for the building and repairing of tissues, and also serve for the maintenance of heat and energy.

The carbohydrates and fats yield heat and energy. The mineral salts are essential to life and health, and for the formation of the skeleton and tissues. Water is as essential a food as the foregoing, and serves for the solution and conveyance of food to the various parts of the body, and also for the removal of the waste products formed in the body, viz., the solid and liquid excreta. Water alone, by its evaporation from the skin, assists in stabilizing the temperature of the body.

A part of the water required by everyone is contained in the solid food taken, of which it forms a very large proportion; meat, for instance, contains about 75 per cent water, some vegetables as much as 90 per cent, and bread about 38 per cent.

The amount and the particular kind of foodstuffs required by an individual will vary with his age, his build, his work, and the climate in which he works.

In cold climates a man will require more of the heat-producing foods, especially fats, and in a hot climate he needs less of the nitrogen-containing foods and fats, and more of the vegetable foodstuffs.

The greater amount of muscular energy required, the greater will be the amount of food necessary to supply this energy.

The energy value of food is generally expressed in large or kilo-calories, a large calorie being the energy, in the form of heat, required to raise the temperature of 1 kilogram of distilled water from zero to 1° C.

It has been found by experiment that 1 Gm. of protein or carbohydrate is capable of yielding, by its oxidation in the body, 4.1 calories, and 1 Gm. of fat, 9.3 calories.

Daily menu.—It is advisable to prepare the daily menu at least 24 hours in advance. It should provide food of satisfactory quantity, quality, and variety.

There is often a tendency for cooks to prepare an excess of stews, which may cause dissatisfaction among the men. When on the march or otherwise heavily worked, the men will have a craving for sweets; a liberal amount of jam should be provided to satisfy this craving.

The presence of much refuse food in the garbage can is a good indication that the men are not receiving the proper kind of food, that it is not palatably cooked or served, or the quantity is excessive.

The field ration should contain tomatoes and lemon or orange juice whenever practical. Potatoes should be cooked and eaten unpeeled, thus supplying additional vitamins. Fruit and vegetables which are to be eaten raw and unpeeled, should have the exterior surface sterilized by temporary immersion in boiling water whenever there is suspicion of soil contamination being present.

Every effort must be made to vary the field diet to the greatest possible extent, changing the food substances as well as the manner of cooking.

The guard at night should have coffee and bread before going on duty, and this should apply to relief parties.

Field kitchens.—The use of rolling kitchens on the march has superseded the old method by which each man cooked his own food. One rolling kitchen supplies food for 200 to 250 men. The field kitchen should be located on the opposite side of the camp from the latrines and urinals. Some means should be used to protect the food from dust and sand. If circumstances permit, the kitchen should be screened; if not, other precautions should be taken to protect food from flies and other insects. Burlap sacking may be used for screening when more suitable material is not available.

There should be on hand at all times a sufficient supply of pure water and material for cleaning purposes, such as soap, soda, and soap powder. Scouring material, boiling water, and dishcloths should be available.

If the kitchen has a dirt floor it may be oiled with used motor oil to control dust.

The cooks and other attendants working in the kitchen and handling food should be instructed and trained in personal hygiene. Food handlers should be required to wash their hands thoroughly after each trip to the latrine. Rigid supervision is necessary to prevent the cooks from becoming lax in personal cleanliness, especially in keeping the hands and finger nails clean.

Physical examination of all food handlers should be made at regular intervals, and, if the laboratory facilities permit, an effort should be made to detect and eliminate any disease carriers among them. Frequent venereal inspections also should be made.

Liquid and solid refuse should be disposed of as soon as possible. The outside of all garbage cans should be kept clean, and covered at all times.

The object of cooking processes is:

(*a*) To make food more digestible and appetizing; and
(*b*) To destroy germs and parasites.

Mess halls.—The mess halls should be located near the kitchen and all possible provisions to protect the food in the mess halls from flies, dust, and sand, using wire screening if available, must be taken.

Clothes and toilet articles must not be stored in kitchens or mess halls.

The mess tables should be cleaned and sunned at regular intervals and care must be taken to see that food particles do not collect in the cracks of the tables.

One of the best methods to prevent the collection of food particles in the cracks of the tables is to construct the tables with a removable center board which may be lifted off, and thus permit the cleaning of the cracks between the boards. Another method is to construct the tables with a 2-inch space between the boards.

Washing mess gear in the field.—After meals all mess gear should be sterilized in boiling water. In a semipermanent camp the mess gear may be placed in wire racks and washed by immersion for 5 minutes in water that is kept boiling.

On the march and under conditions where the mess kits from the haversack are in use, the following method of washing the individual mess gear is employed:

Immediately after the men have finished eating they should form a line and pass a garbage can or pit where the refuse liquid and solid foods are disposed of. After disposing of this refuse food each man inserts his mess gear successively in three cans. These cans are placed over a trench in which a fire is burning. The first and second cans contain boiling soapy water, while the third can contains boiling clear water. A few moments insertion in each of these cans is usually sufficient to cleanse and partially sterilize the utensils. After

insertion in the third can, the mess gear dries by its own heat almost immediately and no wiping is necessary. Care should be taken to see that the water in each can is kept at a boiling point, as lukewarm dishwater is a potent factor in the dissemination of saliva-borne diseases.

Protection, storage, and inspection of food supplies.—Surplus and reserve food supplies should be protected from insects such as flies and roaches, from dust and dirt, and from rats and mice. Perishable foods should be stored at a temperature that will inhibit the growth of molds and bacteria. For camps of less than 1 week's duration, storage devices for preservation of food are not necessary.

1. In temporary camps food may be stored in watertight containers and immersed in springs or streams, care being taken to prevent water contamination. Food may be buried below the surface of the ground where the temperature is lower, lining a pit with burlap, and placing boards on the bottom. In addition, food containers suspended from trees or tripods and underground ice boxes provide satisfactory means of protecting and storing food.

A suspended food container consists of a screened box that permits free circulation of air but prevents contamination by insects. The cooling effect is increased by wrapping the box in burlap which is kept damp. Fresh meat, bottled milk, and vegetables may be temporarily stored in such a container. It should not be used where the air contains any considerable amount of dust.

2. In semipermanent camps fresh or cured meats, milk, and vegetables should be kept in an underground storage room constructed similar to an old-fashioned root cellar. The floor consists of well-tamped earth, or boards may be used. The walls should be boarded. Ventilation is secured by windows at the ends or an outlet through the roof. Vegetables should be kept in vegetable bins, constructed of spaced slats to permit the circulation of air. The bottom should slope sufficiently to permit the older vegetables to be used first.

Canned goods should be kept in the storeroom adjacent to the kitchens. Bread boxes which permit aëration of the contents should be used.

The quality of meat can be recognized by the appearance, odor, and texture. Good meat is firm to touch, moist but not wet, and is red in color for beef, pinkish brown for veal, dark pink for mutton, and light pink for lamb and pork. Good meat has a fresh, agreeable odor.

The fat should contain no watery juices or jelly, and should be firm and white. The fat interposed between the muscle fibers gives the meat a mottled appearance.

In the field, inspection of the freshly-killed carcass may be necessary. The most likely place to look for signs of disease is the chest cavity, and to a lesser extent the abdominal cavity; adhesions of the lining membrane indicate inflammation, probably tuberculous.

When decomposition of meat is suspected trim off the tainted parts of the quarter of beef and sink a probe into the shoulder or hip joint. The odor of the probe will determine whether decomposition has set in. A whole quarter of beef should not be condemned because part of it has begun to decompose, as it is often possible to trim off the tainted portion and serve the remaining wholesome portion.

The Eber test (ammonia test) is used to detect decomposition. Place 2 cc of reagent (1 part ether, 1 part concentrated hydrochloric acid, and 3 parts absolute alcohol) into a test tube and shake. A small piece of meat to be tested is lowered to within one-fourth inch of the surface of the reagent. If ammonia is present white ammonia chloride fumes will appear around the specimen.

Meat may be hung in cold storage but it should not be stacked in the refrigerator until it has been thoroughly chilled, preferably frozen thoroughly. When warm meat is stacked in the refrigerator decomposition develops in the center part of the stack before it can be frozen. The hind quarters and fore quarters should be stacked to permit issue alternately.

In the field a percentage of the rations is issued in tin containers, which, due to improper preparation, exposure to excessive heat, and lack of care in handling, frequently undergo decomposition and are especially dangerous to health if their use is permitted. Therefore a careful inspection of all canned goods should be required.

The terms "springers" and "swells" are applied to bulged, blown, or swelled cans. These cans, when pressure is applied at the ends give a crackling sound. "Springers" are caused by overloading the can, and though not desirable, the contents are fit for use. "Swells" are caused by the formation of gas, due to decomposition and may be differentiated from "springers" by a splashing sound when the can is shaken, and a hollow note when the can is gently tapped. These should always be condemned.

Occasionally the inside of a can may present a blackened appearance—so-called "can burn." This condition is not due to putrefaction, but is caused by the precipitation of stannous (tin) sulfide in an acid medium.

Formerly a can with two solder holes was indicative of a "swell" which had been punctured to let out the gas and then resoldered, but now many manufacturing firms use two solder holes in sealing their cans. It is well to reject cans with three solder holes.

Vitamins.—Vitamins are accessory food factors that occur in minute amounts in natural foods and are in varying degree essential for normal body growth and maintenance. They are discussed in the chapter on Diets and Messing for the Sick.

Conservation of food vitamins.—Several simple but important facts must be remembered in providing troops with an adequate intake of vitamins. Personnel charged with preparing food for consumption should be familiar with these facts and conserve food vitamins. The vitamin content of foodstuffs decreases with age and exposure to heat, light, oxygen, and alkali. Since vitamins are water or fat soluble, the water or fatty liquids in which foods are preserved or cooked contain vitamins and other beneficial extractives which should be incorporated in the ration, if possible, rather than discarded as waste products. Prolonged cooking, such as is apt to occur with field kitchens, tends to destroy the vitamin content of the ration. The vegetables for stew should be cooked separately and not longer than 30 minutes; then they should be added to the meat, which requires about 2 hours of cooking. Avoid the use of alkali, e. g., sodium bicarbonate, when cooking green vegetables as it tends to destroy the vitamins.

The vitamin-containing foods of an exclusive military ration should weigh at least 30 per cent of the total.

WATER

Responsibility for water supply.—The quartermaster is responsible for the procurement of water rights and for the delivery of water to the camp site. The medical officer is responsible, in an advisory capacity, for the quantity and the quality of the water at the source as well as at the ultimate point of consumption. The unit commander is responsible for the proper distribution of the water within the organization.

Water consumption.—Water constitutes 60 per cent of the body weight, or the equivalent of 10 gallons, which equals 100 pounds approximately in the average

man's body. The loss of 1 gallon of this water has serious consequences; if 1½ gallons are lost, the result is fatal. (The volumetric measures used here are Imperial).

The quality and quantity of the water supply is a vital factor during field operations. In a war of movement the supply of water is very apt to be inadequate, which may mean that the consumption of water will have to be restricted to a minimum.

The minimum allowance of water for the needs of men and animals varies according to the amount of daily labor performed and also the conditions of the weather. The following may be taken as an absolute minimum: Each man, 1 gallon per day, to be used as follows—1½ quarts for drinking, 2½ quarts for cooking and drinking with meals. In combat, a soldier can maintain physical efficiency for 2 days only on one-half gallon of drinking water each day.

This is the minimum for soldiers on the march and in bivouac, and provides no allowance for the washing of person or clothing.

In camps of more than 1-night duration the following minimum allowance should be furnished:

	Gallons
In barracks	20
In camps	5–10
Drinking and cooking only	2

The daily requirements for animals are:

Horse	10
Mule or donkey	6

Source of water.—The sources of water are divided into (*a*) surface waters, such as lakes, ponds, rivers, streams, etc.; (*b*) ground (underground) waters, which include wells, springs, etc.; all these vary in degree as to purity and potability. Rain water is usually the most satisfactory of all natural waters. Large bodies of water are more likely to contain pure water than small ones, because of the greater dilution of the contaminating material. Water which is obtained from the center of a large lake is very apt to be pure, especially where the sun shines upon it.

One should always be suspicious of all surface waters as the appearance of water is no index as to its purity. Water should be considered contaminated until tests prove it potable. Also, water found potable may become contaminated subsequent to test. Consequently, water used for drinking and cooking purposes should be guarded and tested frequently for contamination.

Wells are of two varieties, "deep" and "shallow." Water taken from shallow wells is always suspicious, while water taken from deep wells and deep springs is usually fit for human consumption.

1. If water from a running stream is used, it should be taken from a point where there is considerable depth, and where the current is strong, always upstream, or in other words, above the campsite. Upon arrival in camp, a guard should be posted over the water supply and the stream should be inspected and marked for use. Beginning upstream the water should be assigned for use as follows: (*a*) Drinking and cooking water; (*b*) Water for animals; (*c*) Water for bathing; and (*d*) Water for laundry purposes.

To compute the volume of water of a flowing stream the following may be used as a guide: *Sectional area in square feet, multiplied by 0.8 velocity in feet per minute, multiplied by 7.48, equals the flow in gallons per minute.*

2. Rain water, though not very palatable, is the safest and purest of waters. In warm countries it may be necessary to use it for drinking purposes but it

must be properly collected and stored. Rain water is easily collected from the roofs of houses or other prepared surfaces. These surfaces must be kept free from pollution, such as excrement of birds, dust, decayed leaves, etc. The first washing of the rain should never be used as it will probably contain some pollution from the roof. In storing the rain water, the containers should be well-screened and ventilated, and frequently cleaned to prevent pollution. One inch of rainfall produces 22,500 gallons of water per acre. The number of gallons of rain water expected to be recovered from a roof may be determined by the following formula: *Area of roof in square feet, multiplied by one-half the rainfall in inches, equals the number of gallons.*

3. Well water usually comes from two sources. The greater portion filters in from the deeper strata of the soil and may be considered as free from contamination. However, wells are rarely properly encased near the surface and properly covered as protection against surface water drainage and other pollution. Therefore all wells should be regarded as contaminated and should be cleaned and disinfected prior to use by employing the following measures:

(*a*) Remove all refuse from well.
(*b*) Pour into well about one-half barrel of a solution of freshly burned lime (or a 1 per cent solution of chlorinated lime can be used).
(*c*) Scrub sides of well with this solution.
(*d*) Wait 2 hours, pump well dry, and repeat above procedure.
(*e*) Wait 24 hours, pump out well, allow to refill.
(*f*) Continue to pump out until all taste of lime has disappeared.
(*g*) Sterilize water in well by adding a solution of chlorinated lime—30 grains to every 100 gallons of water in well. To compute the number of gallons in well use formula: *The square of diameter of well in feet multiplied by 0.7854, multiplied by depth of well in feet multiplied by 6.25 equals gallons in well.*

Transportation and storage.—Water carts employed in the transportation of water should be subjected to the following sanitary measures:

(*a*) The tank of water cart should be scrubbed out every 4 days with a 1 per cent solution of chlorinated lime.
(*b*) Water carts should never be devoted to other purposes than to provide drinking water for men.
(*c*) A half teaspoonful of chlorinated lime—30 grains—well dissolved as a paste, added to 100 gallons of water will produce approximately 1 part per million of free chlorine, and is sufficient to sterilize this quantity of water.

The best storage containers are those made of concrete, slate, or galvanized iron. Wooden containers will, after a time, give the water a very disagreeable taste. Water receptacles should be well covered. As the ground in close proximity to a water faucet is likely to be wetted, it is best to build a sand or gravel pit, 2 feet square and 1 foot deep, to absorb the waste water.

The receptacles should be cleaned daily with boiling water, or rinsed with a solution of potassium permanganate (one-third teaspoonful to 1 gallon of water). A solution of chloride of lime is also very good for this purpose, in proportion of 1 to 1,000. These solutions are harmless and more certain in their action than boiling water used alone.

Canteens, when not in use, should be emptied, dried, and cleaned with one of the above solutions. Weak tea has been highly recommended for drinking purposes in canteens; it should be boiling hot when poured in, thus insuring the sterility of the canteen as well as of the contents.

Common drinking cups should not be used; however, if individual drinking cups cannot be supplied, lip drinking should be practiced. Should conditions arise which make it absolutely necessary to use common drinking cups, a certain degree of safety can be insured by keeping the cup immersed in a 1 per cent solution of formaldehyde.

Purification of temporary water supplies. *General.*—The water supply for moving troops, for temporary camps and installations, or for troops in the theater of operations frequently must be purified under conditions which do not permit the installation of permanent or semipermanent water purification works. The agencies employed generally for this purpose are: 1. Chemical; 2. Heat; 3. Filtration.

Chemical purification.—Chlorination is extensively practiced today. Hypochlorite of calcium, commonly called bleaching powder, is the substance used, and is issued by the quartermaster in small glass tubes.

The ordinary calcium hypochlorite (Calx chlorinata) or bleaching powder, contains 33⅓ per cent of available chlorine when freshly prepared, but is an unstable substance, so that the supply received may contain but little chlorine. There are hypochlorites available however, and now recommended for use, which contain well above 60 per cent available chlorine, are very stable and easily miscible. Bleaching powder tends to form small, hard lumps when placed in water. In preparing a hypochlorite solution just sufficient water should be added to the powder to permit the easy formation of a smooth, thin paste, which is then diluted as required and placed in the chlorinator. Twenty-five pounds of ordinary bleaching powder added to 1,000,000 gallons of water give one part per million of chlorine. If 4,000 gallons of water are to be chlorinated one-tenth pound of hypochlorite is sufficient. A drip chlorinator may be used in a small stream, the size of the containers and the strength of the solution being determined by the rate of flow of the stream, however, the drip chlorinator is not recommended. In case water is so turbid as to make it unsatisfactory for use, it may be clarified by allowing it to stand for some time in a reservoir and clarification may be hastened by the addition of chemicals. Alum, lime, and soda ash are used for this purpose.

Chlorinating water for small detachments.—Small detachments separated from the main body of troops and its pure water supply may be provided with safe water by chlorination of canteen water. The contents of one tube of calcium hypochlorite are dissolved in 1 quart of water and preserved in a glass bottle. A metal container is not used as the concentrated calcium hypochlorite has a chemical action on the metal. One teaspoonful of this solution added to 1 canteen of water and allowed to stand for 30 minutes renders the water safe for drinking. If the tubes are not available, then dissolve 1 teaspoonful of chlorinated lime taken from a freshly opened container, in 1 quart of water and label this "stock solution." This solution deteriorates very rapidly and fresh solution should be prepared every fourth day. One teaspoonful of this stock solution added to each gallon of water and allowed to settle for 30 minutes will insure the destruction of most bacteria.

Sterilizing water by iodinization.—Two and one-half teaspoonfuls (10 cc) of 7 per cent tincture of iodine added to a sterilizing bag of water will purify it in 30 minutes. Two drops of the tincture added to one canteen of water and allowed to stand for 30 minutes will render it pure.

There are two objections to this method of sterilization:

1 There is no reliable method for titrating the iodine in a test for sufficiency of the amount added; and

2. This method is more expensive than the hypochlorite method. (The excess of iodine may be neutralized by adding 1 gram of sodium thiosulfate.)

Water sterilizing bag.—The water sterilizing bag, often called the Lyster bag, is made of specially woven, waterproof canvas, weighs about 7 pounds, and can be folded into a compact package. It measures 20 inches in diameter and 28 inches in length, and holds about 36 gallons. (Fig. 135.) Its sole use is as a stationary receptacle for water while being sterilized and distribution of same after sterilization, without dipping. This is accomplished by faucets which are arranged around the bottom of the bag. The Lyster bag is part of the Marine Corps field equipment and is issued on the basis of 1 bag for each 100 men or fraction thereof.

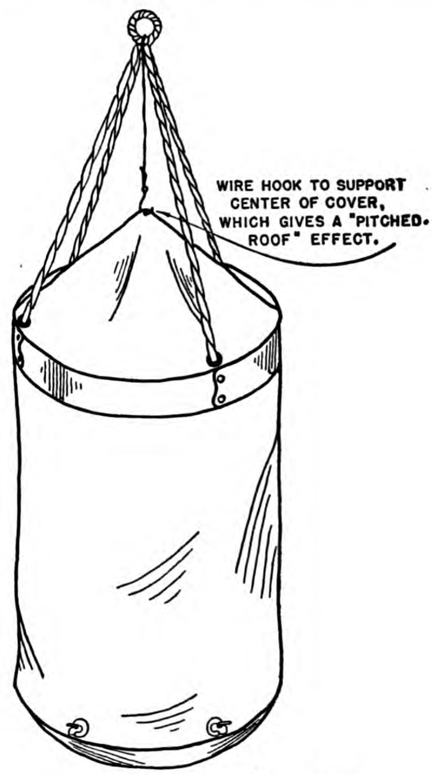

FIGURE 135.—Water bag.

In use, this bag is suspended from a tripod and filled with water. To each bag of water (36 gallons) there is added the contents of 1 ampule of calcium hypochlorite. The calcium hypochlorite is issued in sealed glass tubes, one tube sufficing for one bag of water. The water is then allowed to stand for at least 30 minutes before using, as the sterilizing process is one of oxidation, and is not complete in less time. In water that contains much suspended matter, or is very cloudy, the sterilizing action is not very satisfactory so that it is necessary to clarify the water before chlorination which may be accomplished by means of a small filter cloth provided with the bag.

1. Arrange bag on tripod. Strain water and fill bag to within about 4 inches of the top.

2. Procure a clean stick, or cut a limb from a tree for use in stirring of water. Place this in water and leave there during sterilization.

3. Break one of the glass ampules of calcium hypochlorite and shake the powder into a cup. Mix with water until a fine paste results, and then stir with a spoon, adding more water until the paste is entirely dissolved.

4. Add the hypochlorite solution to the contents of the bag and mix thoroughly with the stick provided for that purpose. Draw 3 cupfuls through each of the faucets (to clean and sterilize) and pour back into the bag.

5. Draw off 1 cup of water and add to it the contents of 1 ampule of orthotolidine, stirring with a clean, dry spoon. As the water is stirred it turns yellow, the degree depending on the amount of hypochlorite present. An orange or orange red color indicates a sufficient amount for sterilization. A canary yellow color indicates an insufficient amount and hypochlorite should be added to the bag 1 tube at a time until the right color is obtained. The water is then allowed to stand for 30 minutes and guarded to prevent use during this period.

6. Excess chlorine gives the water an unpleasant taste. This can be dispelled by neutralization with sodium thiosulfate. Sodium thiosulfate is provided in glass ampules. The contents of 1 ampule should be added to a cup of water, stirred until dissolved, and after sterilization of the contents of the bag is complete, should be poured into it.

7. The faucets should then be rewashed for the last time, running at least 5 cups of water through each faucet and returning the water to the bag. This treatment renders the water perfectly safe, even though it was previously heavily contaminated.

8. Unless precautions are taken men will drink directly from the faucets. They should be required to use their individual mess-kit cups.

9. The bag cover may be supported in the center by means of a wire to the apex of the tripod support. This gives a pitched-roof effect, allows rain water to run off the top and prevents sagging of the top and contamination of the contents.

Mobile water purification unit.—The United States Marine Corps has procured two highly efficient mobile purification units, and has placed one on each coast. Essentially the unit consists of the following:

1. Gasoline engine-driven centrifugal pump.
2. Pressure filter.
3. Chlorinator.
4. Soda-ash feeding device.
5. Suction hose and discharge hose.

These are mounted on a circle-steer highway trailer.

The pump has the following capacities:

1. Twenty-five gallons per minute against a 10-foot delivery head through filter.
2. When filtration equipment is bypassed—in case the raw water is sufficiently clear—the pumping equipment and solution feed chlorinator will deliver 50 gallons per minute of sterilized water against a 50 foot head.
3. When filtration and purification equipment is bypassed, and the unit used as a pumping device, then 100 gallons of water per minute can be delivered against a 75-foot head.

Thus the mobile unit may be operated as: 1. A simple pumping unit; 2. A pumping and chlorinating unit; or 3. A pumping and filter unit, with or without chlorinator.

It is rather spectacular to watch the operation of one of these units with the suction hose placed in a muddy contaminated pond of water deliver a clear purified stream of potable water, at the rate of a barrelful each minute, at the discharge hose.

Boiling.—Boiling is a simple and effective method of water sterilization and may be used in the presence of an epidemic of intestinal disease, such as dysentery or cholera, and when materials are lacking for sterilization by other methods.

However, boiling all drinking water entails a considerable amount of fuel and time. For 250 men nearly three barrels of drinking water are required each day and it would be a heavy task upon the rolling kitchen if the boiling is to be done there.

Boiled water has a flat taste unless it is aërated after cooling. Its taste may be improved by the addition of tea or coffee.

Each man can boil water in his canteen, by placing the canteen full of water in a fire, or upon hot coals until the water boils, after which it is removed and allowed to cool. Troops can, after a day's march, prepare their canteens full of boiled water for use on the next day.

Field filters.—The barrel filter consists of a small barrel inserted into one of larger dimensions and separated from the bottom of the larger barrel by about 3 inches of fine sand. The smaller barrel having a perforated bottom, is placed upon the sand in the larger barrel; then more sand is placed around the small barrel to the height of about 6 inches. A layer of charcoal and a layer of gravel may be placed above the sand.

The barrel filter may be sunk into a lake or spring; water may also be filtered by pouring it into the larger barrel.

In connection with drinking water, special attention should be given the following:

1. Regard all water in the field as contaminated unless proved otherwise.
2. Do not let the men fill their canteens from any unauthorized source.
3. Place a guard at the source of the water supply to prevent its pollution.
4. Water discipline on the march should be rigidly enforced.
5. Remember that not only the quality of the water supply but also its quantity should be supervised by the medical officer.
6. The amount of water lost by evaporation, and otherwise, by a man marching for 1 hour, or 3 miles, is nearly 1 pint.
7. The results obtained by modern military organizations demonstrate that water-borne diseases are preventable.
8. The prevalence of a water-borne disease in a camp indicates a weak link in the chain of sanitary measures.

FIELD CONSERVANCY

"Field Conservancy" is a technical term employed to designate the disposal of waste products in the field.

The disposal of waste products is one of the most important field sanitary measures, and the importance of proper waste disposal was known to the ancients.

Burial was the earliest means of disposal and is instinctive in many of the lower animals.

Field sanitary measures of modern military preventive medicine have reached a stage in development in which it is now possible to assemble a million men in the field and prevent decimation by epidemics.

Waste products may be divided as follows:

1. Refuse:
   (*a*) Garbage.
   (*b*) Rubbish (boxes, paper, etc.)
2. Excreta:
   (*a*) Night soil (urine and fæces).
   (*b*) Manure (stable litter).

Or they may be classified as follows:

1. Solids:
   (*a*) Human fæces.
   (*b*) Kitchen garbage.
   (*c*) General camp rubbish.
   (*d*) Stable refuse.

2. Liquids:
   (a) Urine.
   (b) Kitchen sullage.
   (c) Ablution water.

The proper disposal of waste constitutes one of the most important functions of the field sanitarian.

In the disposal of waste the following objectives are involved:

1. *Prevention of insect breeding.*—To change the nature or location of waste matter so that fly breeding will be prevented, and also the breeding of other disease-carrying insects.

2. *Destruction of microörganisms.*—To destroy or otherwise eliminate the presence of organisms which may cause disease.

3. *Removal of a nuisance.*—Waste matter and filth are almost synonymous terms; and, as such, the accumulation of waste creates a condition which is offensive to the senses of sight and smell.

The methods for ultimate disposal of waste products can be grouped into two main procedures, namely:

1. Burying:
   (a) Shallow—Temporary camps.
   (b) Deep—Semipermanent camps.
2. Burning—Permanent camps.

In camps not of a permanent nature and with moving troops, burial is a more convenient and rapid means of waste disposal and is universally practiced in modern armies. Incineration has the advantage of complete destruction of all waste and is the better method, from a sanitary standpoint, for permanent camps.

Collection and disposal of refuse.—Metal garbage cans, if available, should be placed at intervals in the company streets for the disposal of waste paper, burnt matches, cigarette stumps, fruit peelings, etc. The use of receptacles of this sort accomplishes primary cleanliness of the camp and inculcates the habit of cleanliness in the men. If metal receptacles are not available, wooden or cardboard boxes may be employed.

Garbage cans should be well covered and placed on raised platforms at least 2 feet from the ground. The soil beneath these platforms is easily contaminated by the overflow of drippings, and requires careful supervision to prevent pollution and fly breeding. The surface beneath garbage cans should be scraped daily and shoveled into the garbage cans. Fresh dry earth should be spread over the scraped area. The promiscuous use of lime to cover filth is not recommended.

Shallow burial.—The surface of the earth usually consists of bacterial soil varying from a few inches to a few feet in depth. The top layer of the earth's surface is inhabited by millions of friendly germs—the germs of decomposition—which break up organic matter into various gases and water, and so rid the earth of the debris which would accumulate on the surface. (*See* p. 436.) It is part of the scheme of Nature that it must be so, for if constant breaking up of organic matters were not going on, the surface of the earth would become choked and one would find himself up to the middle in leaves, which fall and accumulate.

The surface of the earth is always assisting in this destruction of organic matter. This layer of germ-charged earth is known as the live humus or living filter, because the germs not only destroy organic matter, but they prevent the passage of filth into the soil. The live humus varies in depth according to the nature of the soil, and is deepest where the soil is very light and where air can

percolate through the surface, in which case it may reach to a depth of 2 or 3 feet. Usually, the depth of this humus-bearing soil is 1 to $1\frac{1}{2}$ feet. Below the level of the live humus the earth is sterile or free from germs, and, if buried deep, organic matter such as excreta receives no assistance from the earth in the matter of decomposition. The live humus varies in its intensity from time to time, for if the germs are well fed they increase and multiply, whereas if they are starved they perish.

Germs require food, moisture, and warmth for their growth, and if well supplied with these they will multiply in proportion to the amount of food they obtain. Thus the live humus varies in intensity according to the time of year, for in a very dry summer, when the surface of the earth becomes bone-dry, decomposition may be absolutely arrested, and a body may become mummified or sun dried if it is covered with sand to keep off flies. (Moss-Blundell.)

The Allahabad system.—Nitrification of excrement in the soil is the sole aim of sanitary science, and the more intimately the excrement is mixed with the dry earth the quicker will nitrification occur. (*See* p. 437.)

The germs which cause nitrification are in the upper few inches of the soil and this fact is taken advantage of in the disposal of excreta by the so-called Allahabad system, as used in India.

An area 16 feet long and 5 feet wide is excavated to the depth of 3 inches. The excavated soil is placed at one end. The denuded area is then loosened to a depth of nine inches. The area is sufficient to dispose of 60 gallons of night soil, when dumped in the center. The liquid waste is absorbed by the loosened soil. The solid matter is spread over the area, and then covered with the 3 inches of soil previously removed. This is tamped down.

In a few weeks, depending on the temperature, the solid matter is completely decomposed and all pathogenic germs are destroyed.

The Allahabad method is useful in permanent campsites—using the bucket system—where fuel is limited for incineration, but under the usual field conditions this method is of more academic interest than practical value.

Shallow latrines.—*On the march:* A marching column is supposed to rest for 10 minutes every hour on the march, and during the rest period the medical officer should see that some place is provided for the men to relieve themselves. As soon as the column halts, a sanitary detail from the company should immediately proceed to improvise latrines. A few narrow trenches about 8 inches deep and 1 foot wide will suffice, and can be hastily constructed with a sharp stick, spade, or bayonet. The sanitary detail should remain behind to fill in the latrines with earth when the march is again resumed.

In temporary camps: Camps which are to be occupied for 15 days or less should be provided with "straddle trench" latrines with dimensions as follows: 1 foot wide, 2 feet or less deep, 3 feet long. The straddle trenches are also called the "One-two-three" latrines because of their dimensions.

These shallow trenches are more effective in disintegrating solid waste than the deep trenches, as the germs of nitrification are found only in the upper few inches of the soil. All excretions and disease-producing organisms, even the toilet paper, disappear in these shallow trenches in 4 to 5 weeks, as one investigator reports.

Straddle-trench latrines should be constructed parallel to each other and should be 3 feet apart; the loose earth should be heaped close to one end of the trench. A shovel, spade, tin, or other similar article should be on hand, and each man should be required to cover his dejecta with loose earth after defæcation. In addition straddle-trench latrines may be sprayed with crude oil or covered with quicklime, and then covered with a layer of earth daily.

Often it is necessary to establish a guard in the sanitary area to prevent this weak link in the chain of sanitation. The straddle trench latrine may be designated the open shallow latrine. Sixteen feet of trench should be provided for each 100 men.

Deep latrines.—The open, deep latrines, similar to those used during the Spanish-American War, and which created such insanitary conditions and contributed to the spread of typhoid fever, will be omitted from discussion, for quite obvious reasons.

In semipermanent and permanent camps deep, covered latrines are recommended.

These latrines require more time and labor to construct than the shallow-trench latrines, but have the advantage that they are easier to make fly proof.

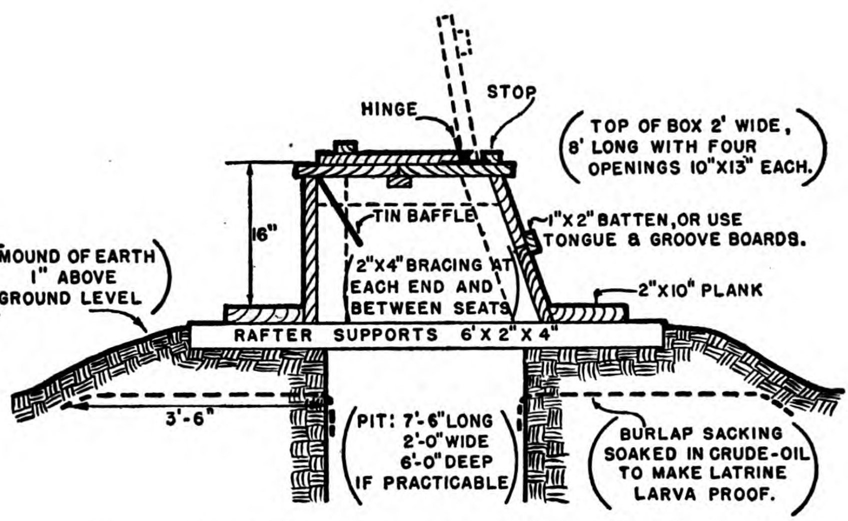

FIGURE 136.—Modification of standard U. S. Army latrine box.

The dimensions for deep latrines vary considerably, but the following may be taken as a standard: 2 feet wide, 6 feet deep, 7½ feet long.

In loose soil it may be necessary to revet or face the latrine pit.

The Army latrine box is an excellent type of cover for deep latrines. The exact specifications for building this box will be found in figure 136. The box consists essentially of an inverted open box built to a convenient height above the ground, containing pear shaped holes in the top, with lids covering these holes. The lids are made to open not over 85°, which will cause them to close automatically. A space of one-fourth inch should be left at the seat hinge to allow for the swelling of the wood.

These deep latrines are usually intended for use over a long period of time. Most of the odors of latrines are due to ammoniacal and other decomposition of urine and the separator system is sometimes used to separate the urine from the fæces. A urinal soakage pit is built close by, and by means of a tin gutter, built in front of and under the seat, the urine accompanying defæcation is drained into the soakage pit. A urinal trough connected to a soakage pit should be constructed within the latrine enclosure.

The latrine is improved by erecting it on a mound a foot high composed of earth removed from pit. This mounding of earth prevents surface drainage into the pit causing the contents to overflow. Latrines should be abandoned

when filled to within 1 foot of normal surface level, and when abandoned they should be liberally sprayed with crude oil or covered with quicklime and mounded with earth. When dug in wet soil a foot or two of water often appears in the bottom of the pit. Such water aids in absorption of the contents into the surrounding soil and many such latrines exhibit septic action. Two boxes should be provided for each 10 men.

Site and number of latrines.—Latrines should: (*a*) Be constructed at least 100 feet from the camp, although deep closed latrines may be constructed at a distance of 50 feet; (*b*) Be constructed on the side of the camp opposite to the galley and kitchen; (*c*) If practicable, be located so as to drain away from the water supply; (*d*) Be placed at a safe distance from ditches and gulleys to avoid the overflow which might be caused by a heavy rainfall; and (*e*) Be located to leeward of the camp, if practicable. Separate latrines should be constructed for officers and men.

The seating capacity of the latrine area, as given by various authorities, ranges from 5 to 15 per cent of the command, depending upon the conditions. For commands on the march, stopping for only 1 night in camp and breaking camp shortly after breakfast, a latrine frontage of 1 yard for every 10 men is not an excessive allowance. It is not always practicable to construct this number, and under such circumstances the medical officer should be satisfied with a 6- to 8-per cent frontage, using the latter figure for commands under 500. In a semipermanent camp estimate 1 seat for every 15 men.

The advantage of straddle-trenches is that the sides are not subject to contamination by urine. A trench lasts 1 to 2 days.

For straddle-trenches the frontages required in yards is 6 times the complement in hundreds—that is, 200 men will need 12 yards of latrine frontage. The depth in yards is two-thirds the number of days stay in that camp.

Care of latrines.—When deep latrines are filled to within 1 foot of the surface with excreta, they should be filled in with earth and abandoned. The filled-in latrines should be covered with a mound of earth and labeled with an "L" if practicable. This marking of the abandoned latrines serves to inform future occupants of their site.

The inside of deep-trench latrines should be darkened by the use of tar paper, lampblack, or other suitable material. The use of a dark substance tends to prevent the entrance of ova-depositing flies. This depends upon the principle that flies usually avoid dark places.

The box cover may be removed occasionally and the inside burned out with kerosene or crude oil.

In order to prevent the egress of any fly larvæ which may develop in the depth of the latrine and burrow through the ground around the mouth of the pit, an area of about 4 feet around the pit should be covered with crude oil, or a 5-per cent solution of cresol. A better method is to cover the area with burlap sacking soaked with crude oil.

It is very desirable that some provision be made for the men, especially cooks and other food handlers, to wash their hands after using the latrines. Sufficient toilet paper should always be available.

In order to prevent the possible flooding of latrines by storm water, a shallow trench should be dug around the area occupied by the latrine.

Latrines should be surrounded by a canvas screen or a screen made of shrubbery. Each abandoned latrine should be distinctly marked.

Soakage pits.—Soakage pits are one of the greatest developments in improvised sanitary appliances.

These pits are designed for the ultimate disposal of liquid wastes, urine, sullage water and ablution water. These sanitary expedients should be considered in the establishment of semipermanent and permanent camps.

Ant heaps, or nests of other termites, have been used as ready-made soakage pits, and have been found capable of absorbing 300 gallons of waste liquids in 24 hours.

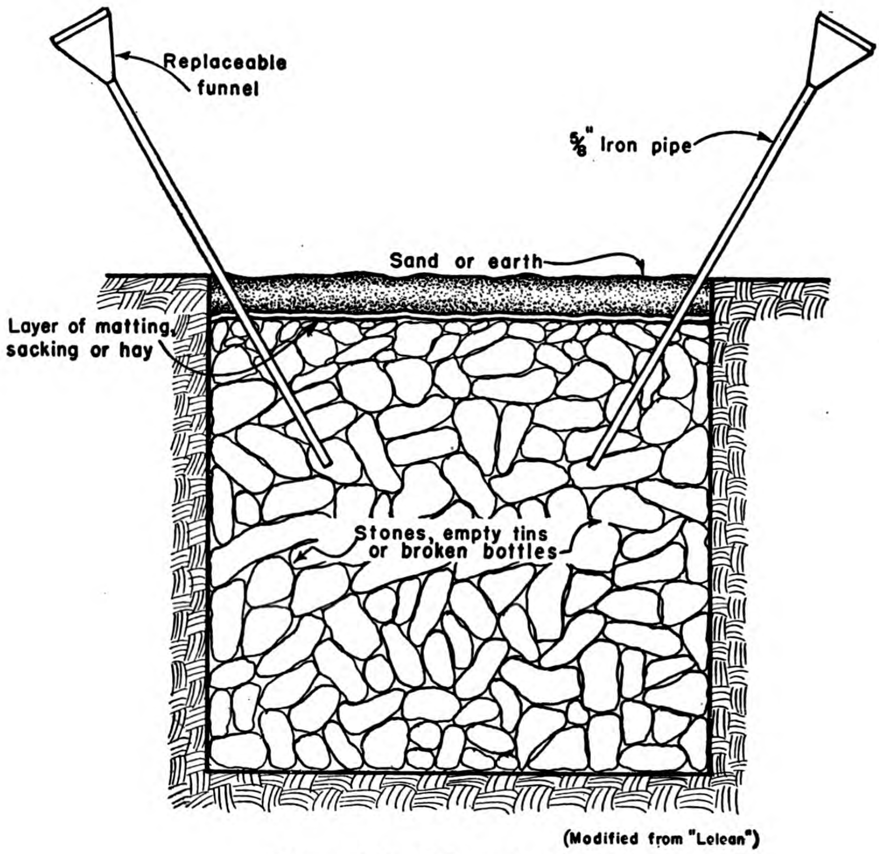

FIGURE 137.—Urine soakage pit.

Urine soakage pits.—(*a*) Dig a pit 4 feet square and 4 feet deep, fill to within 6 inches from surface with large stones, or empty perforated cans.

(*b*) Insert 4 pieces of iron piping, 1 to 2 inches in diameter, and 4½ feet long at each corner of the pit, so that the upper end is at a convenient height above the ground to serve as a urinal. If iron piping is not available, long tin or tar-paper funnels may be improvised for this purpose.

(*c*) Cover stones with oil-soaked burlap sacking, tar paper, or other material.

(*d*) Fill over burlap with earth.

(*e*) Insert replaceable tin funnels in iron piping—preferably with screening over apex of funnel to catch cigarette butts and other debris.

(*f*) Surround urinal pit with white-washed stones to render it more visible at night.

(*g*) A vent leading into the pit may be constructed to give exit to the gases of fermentation and putrefaction.

(*h*) In porous soil, one urinal soakage pit will dispose of the urine of 100 to 200 men for an indefinite period. (Fig. 137.)

Night urinals.—If the urinals are located some distance from the camp, it is a temptation to a man desiring to evacuate his bladder, particularly on a cold night, to urinate upon the adjoining tent, and so on down the company street. To overcome this tendency, urinal cans should be placed in the company streets at night, with a lighted lantern to mark the location. The cans used for urinals should be cleaned and sunned during the day. A more simple type of night urinal can be improvised by making a hole in the center of the tops or garbage containers and placing the inverted tops over the garbage cans.

Sullage pits.—The sullage pit is for the disposal of water from kitchen garbage. These pits are 4 by 4 by 4 feet. They should be fitted with grease traps to remove the grease which tends to clog the interstices of the soakage pit. Figure 138 shows a combined soap and grease trap. Provide a sullage pit for each 200 men.

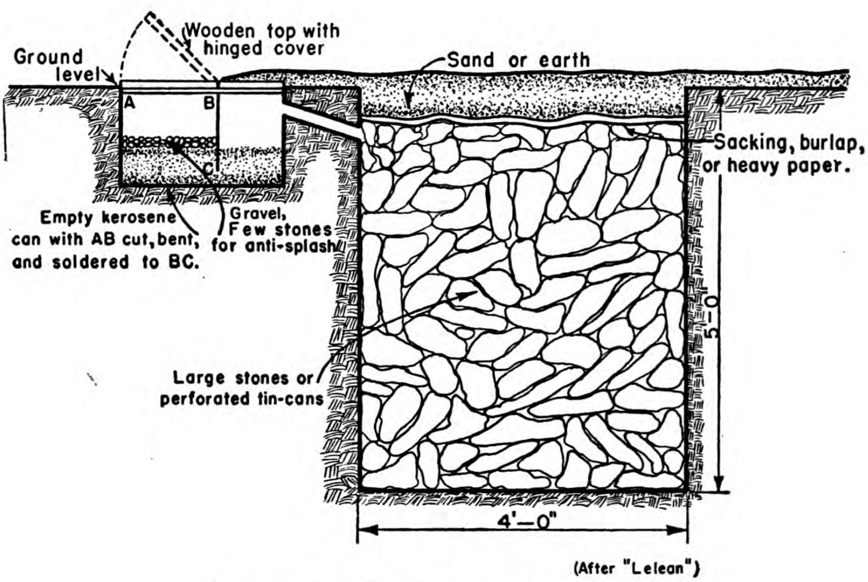

FIGURE 138.—Waste water and grease trap.

In very temporary camps, sand and gravel placed in a can or bucket with perforated holes at bottom will serve to remove the major portion of the grease.

The improvised bucket grease trap may be placed over the open soakage pit filled with stones.

Ablution pits.—If the ablution water is run through a box of fine sand, before entering the soakage pit, the major portion of the soap is removed.

Ash barrel grease trap.—An ash barrel grease trap is prepared by using a barrel of about 50 gallons capacity with 1 head removed, and boring 30 one-inch holes in the remaining head. Place about 8 inches of gravel or stone in the bottom, the size of the stones decreasing from 1 inch at the bottom to ¼ inch at the top, and over this place 16 inches of wood ashes. Fasten a piece of burlap over the open top of the barrel by means of a hoop. The trap may be placed directly on the soakage pit or on an impervious platform which drains into the pit.

The sullage water is poured into the barrel through the burlap, food particles thus being strained out. As the greasy, soapy water filters through the ashes the greater part of the grease and soap will be removed. The burlap should be

removed daily and burned, and it will be necessary to replace the ashes every 3 or 4 days.

When more than 200 gallons of water per day are to be disposed of, additional soakage pits and grease traps may be necessary. One barrel grease trap should be provided for each 200 men.

Disposal of garbage to farmers.—It is sometimes possible to dispose of the kitchen refuse by contract with the farmers in the vicinity to haul it away to use as food for hogs, poultry, etc. This method of removal is satisfactory at times, but at other times it will be found difficult to induce the farmers to remove the garbage at regular intervals, which allows the waste to accumulate and become a nuisance. Under these circumstances it is frequently advisable to resort to other means of disposal and to burn or bury the kitchen garbage together with the other waste products.

Small sewage disposal plant.—In the field, occasions may arise that require the construction of small sewage disposal plants. The "filter type" is recommended as simple and easily constructed. This type embodies the essential characteristics of the method of sewage treatment known as intermittent sand filtration."

1. Excavate a circular pit not less than 5 feet deep and 8 feet in diameter.

2. Line the pit with a wall of stones, old bricks or other suitable material laid up without mortar in joints, leaving a space between this wall and the wall of the pit.

3. Fill in the space between this wall and the natural soil with coarse sand and gravel.

4. Fill in pit with fine gravel to provide a filter bed of at least 30 inches depth and allow 6 inches between bottom of soil pipe and top of filter bed.

5. Construct a suitable roof and sod over it. It is essential for successful operation that the water level be kept well below the surface of the filter, and in rare cases where the soil is nonporous, often joint subsurface drains should be installed.

Incineration of waste products.—Incinerators used for the disposal of waste products may be divided into two types, open and closed. Characteristics of the *open type* are that they are easily constructed, require less material for construction, and are practical for use in semipermanent camps; characteristics of the *closed type* are that they are more quickly started, are not so liable to be put out by rain, are not so productive of bad odors, produce more heat, and are practical for use in permanent camps.

An example of the open type is the **rock pile incinerator** which is constructed as follows: Dig a circular pit 15 feet in diameter and 3 feet deep; line the pit with boulders or mashed tin cans. In the center of the pit raise a pyramid of stones about 5 feet high which will serve to create a draft. A fire is built around the pyramid of stones and the garbage is later thrown on the pyramid where the solid matter is consumed and the liquid is evaporated by the hot stones.

One cord of wood will consume about 4,000 pounds of ordinary camp refuse, after the stones have been heated.

A closed-type incinerator to dispose of all types of kitchen garbage in permanent and semipermanent camps may be constructed as indicated in the accompanying diagram (fig. 139). This incinerator should be constructed about 200 feet away from the kitchen, and in a location where prevailing winds are least liable to blow smoke toward the camp. It is advantageous to build the incinerator in a small grove of trees, if available. Trees serve as a windbreak, preventing scattering of papers, ashes, etc., and aid in carrying the smoke upward.

The incinerator is fueled by logs, the fire hottest at the middle and lower end, to prevent "burning out" and warping of the iron plate. Wet garbage is deposited on the plate near the stack where it steams and dries slowly; agitation with a rake hastens drying. Portions which have become sufficiently dry, and large chunks of material, are raked over on the iron rods where they are burned and fall into the fire box. All but objects such as tin

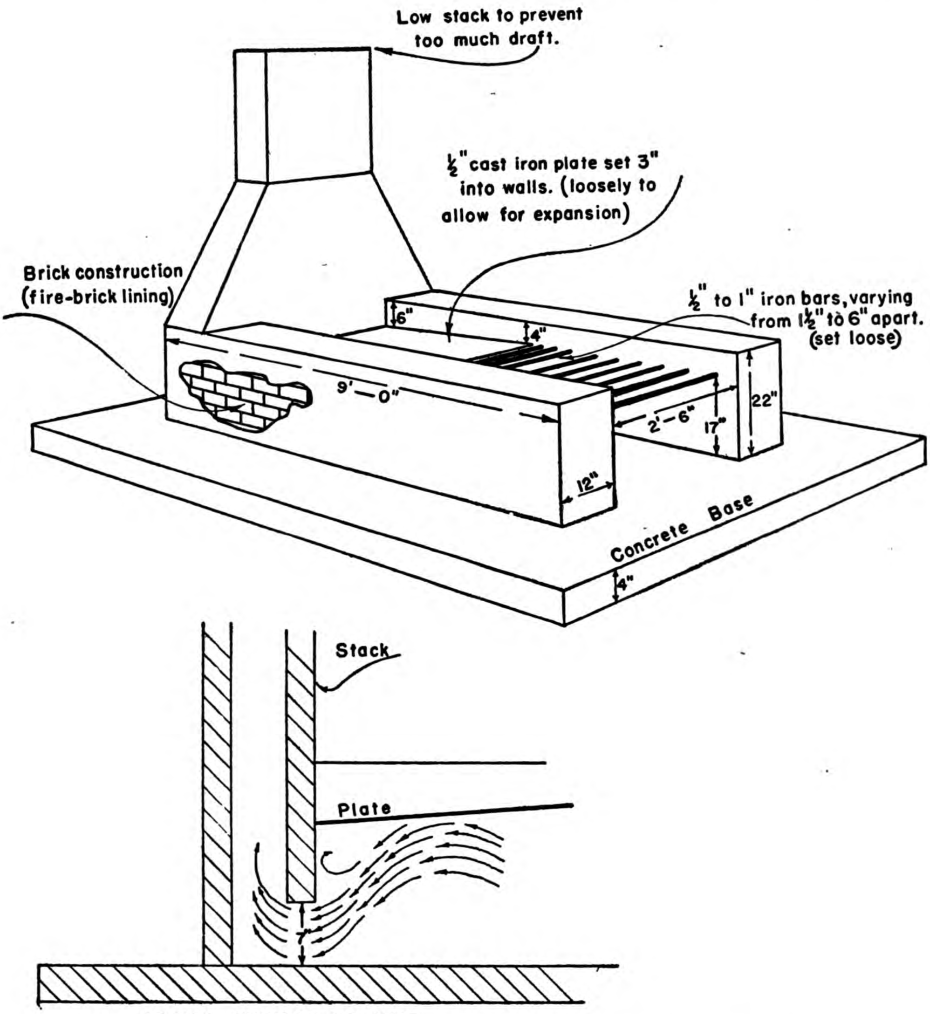

FIGURE 139.—Incinerator for permanent and semi-permanent camps.

cans, etc., are reduced to ashes, which may be cleaned out occasionally and disposed of, preferably by burying. An incinerator of these dimensions should be large enough to dispose of all the waste in a camp of about 100 or 200 men.

Disposal of carcasses of animals.—The labor involved in burying a dead animal is considerable, consequently a combination of burial and burning is recommended.

A hole is dug beside the body, which is then disemboweled and the internal organs are buried.

The disemboweled carcass is then covered inside and outside with 30 to 40 lbs. of dry hay, or other litter, saturated with kerosene, and set fire to. This

method aims at sterilization of the carcass and not incineration. If sufficient fuel, time, and labor are available, complete incineration of the carcass may be accomplished.

Manure disposal.—There are several methods for the disposal of manure, a few of which will be discussed.

Distribution method.—This method is applicable only in warm weather. The manure is spread in a thin layer on hard level ground, care being taken not to have the layer more than 1 inch in thickness. It is raked over a few hours later and all small lumps are broken up. This rapid drying method prevents fly breeding. The manure of 500 horses will require an area of 25 by 25 yards, and three such areas used, one every third day in rotation.

Close packing.—This method is also known as the "bio-thermic" method of manure disposal. In it the manure is moistened with water and closely packed by gradually adding new manure and beating the pile with shovels. The center of the pile undergoes fermentation and heat of more than 150° F. is generated, which heat is sufficient to destroy the eggs and larvæ (maggots) of flies. Flies lay eggs only in fresh manure which is damp, and do not lay eggs in fermenting manure or dry manure. Eggs which are laid in fresh manure hatch within about 24 hours and the maggots migrate away from the hot center of the pile to the cooler outer layers, because contact with heat of fermentation kills them. When the larvæ of the domestic fly are exposed to a heat of 122° F. they die in about 3 minutes. The gases of fermentation kill them in about 1 minute at 124° F., in about 4 to 8 seconds at 139° F., and in from 4 to 6 seconds at 140° F. The daily amount of manure produced by one horse is from 1 to 2½ bushels.

Because of the fact that flies lay their eggs in manure, maggot or larvæ traps are often used in connection with the disposal of manure.

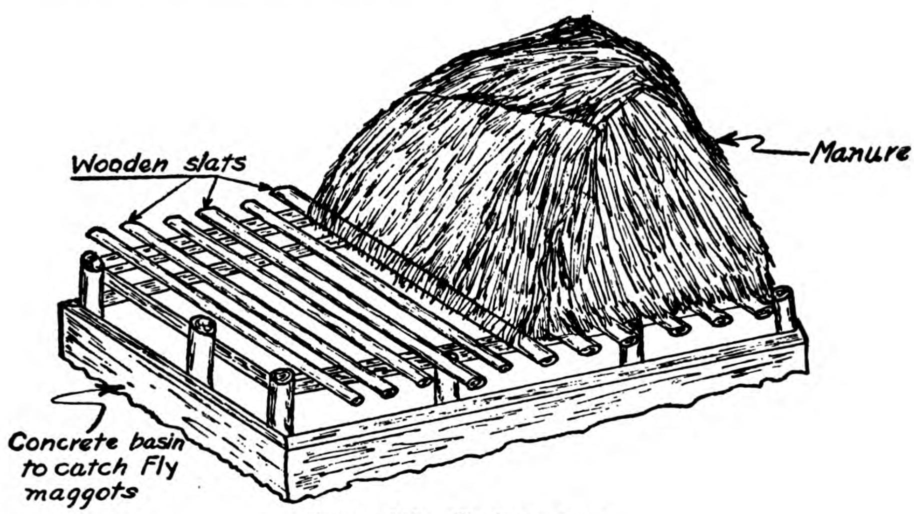

FIGURE 140.—Fly larvæ trap.

Maggot trap.—The manure is stored on an elevated platform composed of parallel slats, underneath which is placed a receptacle containing water or some insecticide solution.

The pile is exposed, thus encouraging flies to lay their eggs. The eggs hatch into maggots, and the maggots burrow through the pile in search of earth, with the result that they fall between the slats into the solution below, where they are destroyed. (Fig. 140.)

Larvæ traps have been designed for use in manure heaps. Empty tin cans with slits of a sufficient size to admit maggot forms are filled with dry hay and sunk into the manure pile so that the slits are flush with the surface. The larvæ seeking a dry spot for pupation crawl into the tins and are later destroyed by burning. Several thousand larvæ have been caught in this type of trap in 1 day.

Incineration of manure.—When the manure is not used as fertilizer, a wire hammock may be improvised and slung between two trees. The requisites are an amount of heavy wire, a pair of wire clippers, and some ingenuity. The manure is thrown on the hammock and burned. The hammock may be swung with a pendulum motion in order to increase the draft, which will facilitate the destruction of the litter. The hammock incinerator was devised at Quantico, Va., and proved a very satisfactory method for the destruction of manure of several hundred horses and mules. If the number of horses is small, an old wire bed-spring may be used as a hammock incinerator.

Another useful method of manure incineration is to place the manure in piles about 2 feet high—known as windrows—sprinkle with oil and burn.

Rails from railroads may be used to construct an incinerator for the cremation of stable refuse.

Persistently wet weather may delay or prevent the burning of manure for some days, and during the rainy season in some countries incineration becomes impracticable.

Manure enclosure with maggot trap.—For cases where the manure is to be stored for some time and later used as fertilizer, there has been devised a manure storage receptacle with a trap to catch larvæ. This is somewhat similar in principle to the maggot trap.

A screened enclosure, 4 by 4 by 4 feet, is erected over a concrete base, surrounded by a trench with overhang to catch and retain fly larvæ. The fly larvæ are fed to chickens, or destroyed by hot water, or chemicals. The trench is connected with a small sump, in order to keep the trench dry. The wetted manure is packed tightly in the wire enclosure, and the fermentation of the organic matter generates heat, so that the fly larvæ, not being able to withstand the interior heat, come tumbling out through the meshes of the enclosure and fall into the maggot-retaining trench below.

FIELD MEASURES FOR INSECT CONTROL

The human race is at constant warfare with hordes of visible enemies—insects, which frequently act as carriers of myriads of invisible foes, pathogenic organisms, and ova of parasites. This is especially true of conditions in the field, and for an expeditionary force to withstand successfully the attacks of insects requires detailed consideration of field measures for insect control.

Flies.

The question of fly control is of tremendous importance in the prevention of disease in the field, so extended remarks on the life history are appropriate.

The development of the fly by metamorphosis has been described on page 447 in the section on Hygiene and Sanitation.

The egg must be kept warm if it is to develop, and it is therefore usually laid in vegetable or fæcal matter which is about to ferment, the rapidity of chemical changes therein supplying the needed heat.

The larva of the fly has no digestive glands, and is therefore dependent upon predigested food or other readily assimilable food—another reason for the fly depositing its egg in fæces. Its most interesting habit is that of bur-

rowing. It does so first to reach moister areas of its habitat; if disturbed, it hides with great speed; finally, in the prepupal stage, it comes to rest an inch or two beneath the surface of the ground in the vicinity of its feeding place. Having reached this haven its skin contracts, hardens, and darkens, thus forming the pupa-case within which the change to the perfect insect takes place.

The pupa remains without food for 4 days while developing into the adult fly. To enable it to escape from the pupa-case and force its way to the surface of the ground, the young adult is provided with a temporary structure, in the shape of a dilatable frontal sac, the so-called ptilinum, the first use of which is to pry open the anterior end of the pupa-case. The young adult then emerges, and will escape through a depth of 6 inches of loose soil, and even through 6 feet of dry sand—the latter being a truly heroic effort.

Anatomy of the fly.—The adult fly has the following anatomical points of interest:

It is provided with a nonpiercing, retractile proboscis through which food is sucked by the powerful pharyngeal muscles.

The salivary glands are large, and saliva is freely expectorated onto dry foods, which are thus dissolved prior to ingestion.

The alimentary tract is provided with no other digestive glands. In addition to the stomach, the insect has a large crop capable of holding a 4 days' reserve of food. The hairiness of body and legs is remarkable. The feet are provided with minute hairs, bristles, terminal claws, and adhesive pads. The latter consists of surfaces covered with multitudes of fine hairs, and moistened by a glairy, sticky substance, by means of which the fly maintains its foothold when inverted. For the conveyance of organisms in vast numbers, it would be difficult to imagine a more suitable apparatus than the fly's foot.

Habits of the fly.—Having had no food for 4 days, the emerging adult fly is so hungry that it seeks the nearest feeding ground, and gorges up to 70 per cent of its weight at a single meal.

Its preference for certain foods is dictated by anatomical considerations. It must either get soluble carbohydrates or predigested protein; the former from kitchens and swill tubs and the latter preferably from fæces. When both sources are available, the latrine and kitchens are frequented alternately, hence the danger in the field from flies transmitting intestinal diseases.

When resting, the fly can often be observed to regurgitate crop contents, until there is suspended from the end of its proboscis a drop nearly as big as its head. This fluid is drawn in and out with gusto so long as the fly is undisturbed, but is dropped if alarm leads to hasty flight. A cropful of fæcal fluid may thus be deposited on the surface of food ready for human consumption. Well-fed house flies evacuate their bowel about once every 5 minutes.

A fly will go upward through a hole, but seldom downwards, and this fact is utilized as a principle in the construction of some flytraps.

Flies endeavor to avoid strong sunlight and tend to congregate in shady places in room light. They likewise avoid a dark place, hence lampblack is used, as a fly deterrent, to cover the interior of latrines.

These insects have a tendency to rest upon vertical rather than horizontal objects; they also prefer curved surfaces rather than plane surfaces. The latter two facts are utilized to catch the adults by suspending curved strips of fly-paper from the ceiling.

Flies tend to select certain colors and shades of color. They prefer a lighter shade to a dark one of the same color and have a tendency to avoid blue colors.

Flies can travel long distances—100 miles or more.

A temperature of 120° F. is usually fatal to flies; they are most active at a temperature between 80° and 90° F. and are torpid at 50° F.

Prevention of fly breeding.—Flies breed in horse manure, excreta, decaying organic matter, and even in dirty rags and paper. One neglected stable may supply a horde of flies for an entire district, as a cart load of manure may harbor as many as 200,000 maggots.

Chickens feed freely on fly larvæ growing in manure, and it has been claimed that six chickens per horse will keep down flies around a stable.

Garbage should be kept in covered containers to prevent fly breeding and should be removed frequently, especially in warm weather.

The suppression of flies resolves itself into a matter of cleanliness—organic cleanliness of the environment.

Grease traps must be covered and the surroundings kept clean and dry, or larvæ will develop there.

The proper care of a picket line is a difficult problem. Daily removal of the manure with cleaning of the picket line and burning over of the area are only partially effective measures in the prevention of fly breeding. The heat of burning over the surface penetrates only from 1 to 2 inches of the ground and fails to kill the developmental forms which may be several inches under the surface. Digging up the picket line and saturating it with crude oil and tamping it down is fairly satisfactory.

Protection of food and personnel.—It may be accepted as a maxim that the presence of an undue number of flies is indicative that food or filth is exposed somewhere in the vicinity.

A marked reduction in the number of flies around the kitchen follows the simple measure of cleaning the outside of garbage cans.

In a permanent camp the kitchens, mess halls, and garbage cans should be screened. In a semipermanent camp screening may be impractical, consequently dependence must be placed upon cleanliness and insect proof containers. Unless the screening of a building is maintained in an efficient state, the use of screens is apt to do more damage than good. Leaking screens (especially cracks around the screen door) frequently convert the building into a large "fly-trap"—flies are able to gain entrance into the building through leaking screens but are unable to get out. Screen doors should be made to open outward and should be in direct sunlight, when practicable. One of the places most apt to be overlooked is the space between the bottom of the screen door and the floor, a defect which may be remedied by using extra battens. Some of the other faults to be looked for include torn screens, warped doors, improper closing of doors, broken door stops, etc.

Destruction of flies may be accomplished by the use of muscicides, fly paper, fly traps, by swatting, etc.

Of the muscicides the following is very effective and is easily prepared:

Formalin (solution of formaldehyde), 50–60 cc, or about 3 tablespoonfuls.

Sugar, 20–25 Gms.

Filtered limewater, 250 cc.

Water, add enough to make 500 cc.

The effect of this solution will not be very satisfactory in a humid atmosphere. The flies should not be given access to water when this solution is used. A 1-percent solution of sodium salicylate will also kill flies.

Fill a dish with the solution and place pieces of absorbent paper in it so that the paper will absorb the solution. As the solution is evaporated more must be added.

A small glass jar about half full of the solution is inverted on a flat-bottomed dish which is covered with about three layers of absorbent paper. This is a very efficient method, as the paper is always kept moist by capillary attraction. A thick rubber band placed around the jar and plate will hold the jar in position.

Fly sprays are effective. The basis of these insecticides consists of pyrethrum in kerosene, or similar hydrocarbons. Use of the standard Navy issue insecticide is recommended.

Fly paper is very efficient for catching flies and is prepared as follows: Heat powdered rosin 8 parts and castor oil 5 parts (by weight); stir well while heating; the mixture should not be brought to a boil. In hot weather the proportion of rosin should be increased. Sugar or honey may be added, but it is not essential. The fluid is spread while hot over glazed paper. The mixture may be painted upon iron hoops or wire strands. Wires so painted will last for 2 or 3 days, when they should be cleaned and recoated.

Fly traps consist of wire-cone, glass-bell, and many other varieties, and are constructed on the principle that flies are attracted by the sense of smell through a dark opening in the bottom or side of the trap; after feeding they attempt to leave by flying upwards toward the light and thus into the trap.

Traps should be lifted a certain distance from the ground to allow free access to the flies and should always be baited with some attractively odorous substance. Molasses in water (molasses 1 part to 3 parts of water) or brown sugar (1 part of brown sugar to 4 parts of water) may be used as bait for flies. Both of these solutions increase in attractiveness when fermented.

The habits of flies should be considered in locating fly traps:

1. Flies will go from sunlight into room light, and will go from a dark room to a lighter one.
2. They congregate on the lee side of a shelter.
3. They tend to avoid certain colors, such as blue.

Judging from the experiments conducted by one observer it would appear that the efficacy of fly traps is largely dependent upon the bait used in them. In these experiments 15 different kinds of bait were used and a total of 45,000 flies was caught.

The following are the results of 7 of the 15 types of bait used; the results of the other 8 kinds of bait are omitted for sake of brevity.

Kind of fly bait:	*Percent of total flies caught*
Fish head	31.34
Overripe bananas	21.30
Bran mixture	20.72
Canned salmon	14.00
Molasses, water, and vinegar	1.00
Sweet corn	.13
Mashes, cheese, and molasses	.10

Putrefying fish, kept moist with one part molasses to three parts of water, is said to make an excellent bait for fly traps.

The conical hoop trap (Fig. 141) consists essentially of a screen cylinder with a frame made of barrel hoops, in the bottom of which is inserted a screen cone. The height of the cylinder is 24 inches, the diameter 18 inches, and the cone is 22 inches high and 18 inches in diameter at the base. The apex of the cone is then cut off to give an aperture 1 inch in diameter.

On the basis of extensive tests, Dr. F. C. Bishopp, principal entomologist in charge, division of insects affecting man and animals, Bureau of Entomology, U. S. Department of Agriculture, reports that this trap is best for effective trapping, durability, ease of construction and repair, and cheapness of construction.

Flies gaining access to kitchens and mess halls should be killed by swatting with fly swatters. Fly swatters consist of a piece of wire mesh, leather or rubber tacked to a long handle.

When rubber or leather is used it should be well perforated. The free edges of the wire mesh may be covered with leather if so desired. Care should be exercised not to swat and crush flies on mess tables, serving tables, butcher's blocks, or on any surface on which food is likely to be placed.

Flies and other insects are sometimes destroyed by electrocution. To do this copper wires are interwoven alternately across an insulated framework and spaced one-fourth of an inch apart on screen doors.

The screens are supplied with a high tension static charge of electricity from a small transformer, which produces a charge of approximately 3,500 volts and less than 0.05 millampere.

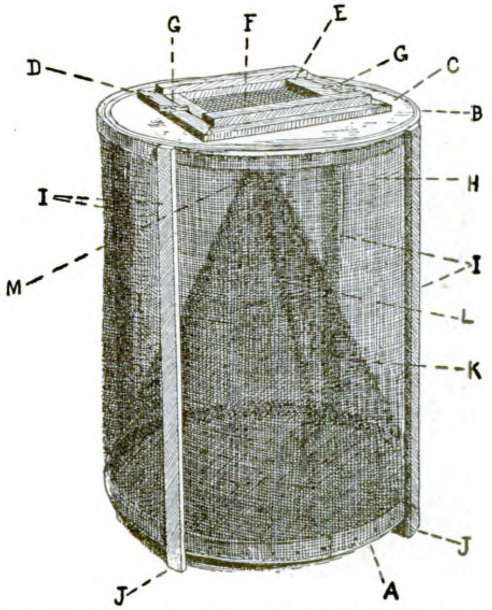

FIGURE 141.—Conical hoop fly trap. (Bishopp.)

These doors are said to have killed as many as 15,000 flies on a summer day.

Mosquitoes.

Different measures are undertaken in the field to combat the activities of the mosquito in the transmission of disease.

Medicinal prophylaxis.—It appears to be the generally accepted opinion that the routine internal administration of quinine as a prophylaxis against malaria is of questionable value, but the treatment of malarial carriers with quinine, plasmochin or atabrine (atebrin) is an important factor in the prevention of the dissemination of this disease.

Personal protection.—Screening of living quarters in permanent camps may be utilized by using mesh screen having 16 meshes to the inch for anopheles—18 meshes to the inch must be used when screening against Aëdes mosquitoes.

The female mosquito, which is nocturnal in its feeding, transmits the malarial germ, consequently sleeping nets are the chief means of reducing the possibility of the transmission of this disease to troops on field duty. This article of equipment is supplied by the United States Marine Corps to every individual of an expeditionary force. If the circumstances warrant, all sentinels should wear head nets and gloves after sunset.

Culifuges.—Kerosene is extensively used in some of the tropical countries as a repellent to mosquitoes, and some of the essential oils, such as oil of citronella, have been used. (One part of citronella to 4 parts of vaseline.) These oils have little practical value in the field as their effect will not last through one night.

A very good insect repellent consists of:

Oleum anisi	2 drops.
Oleum eucalypti	Do.
Oleum terebinthinæ	Do.
Lanolin	1 ounce.

Light shades of color, especially yellow, are repellent to Anopheles mosquitoes which select dark shades, especially navy blue. The Aëdes mosquito prefers a dotted white surface.

Mosquito destruction.—The adult mosquitoes may be killed by fumigation—burning 2 pounds of sulfur for each 1,000 cubic feet of space.

Mosquitoes are infinitely more susceptible to the action of insecticide sprays than flies. The standard Navy issue insecticide is the best spray for this purpose and should be carried in stock by the supply officer or quartermaster.

Mim's culicide consists of equal parts (by weight) of phenol (carbolic acid) crystals and gum camphor. The phenol is slowly melted and then poured over the camphor, thus forming a clear volatile liquid. Volatilize 3 ounces of this mixture for every 1,000 cubic feet of space.

The following formula has been reported as an excellent insecticide spray:

	Parts
Carbon tetrachloride	1
Oil of wintergreen (synthetic)	2
Kerosene	97

Naphthalene—¼ pound added to each gallon of mixture.

Mosquito traps and swatters are sometimes used for the destruction of adult mosquitoes. Destruction of wintering adults is said to be very effective in reducing malaria.

Destruction of mosquitoes in developmental stage.—Mosquito-breeding areas may be controlled by *oiling,* and crude petroleum is the oil usually selected. When the mosquito larvæ, commonly called wiggle-tails, come to the surface for air the oil clogs their breathing apparatus and kills them by asphyxiation.

About one-half ounce of oil suffices for every square yard of water surface under normal conditions, i. e., small areas where the wind does not blow the oil aside. The application of this amount of oil once a week is sufficiently frequent to destroy each crop of larvæ. It requires 10 or more days for the cycle—from the egg to the adult mosquito. For ornamental fish and lily ponds use gasoline, one-half gallon to each 100 square feet.

There are several different methods for oil distribution upon water surfaces:

The "knapsack sprayer" is a well known means of oil distribution, and is often utilized.

The "Panama dripper" consists of an oilcan with a faucet near the bottom which allows the oil to fall on the water, drop by drop (usually at the rate of about 30 drops per minute), and furnishes a means of continuous oiling of a running stream.

The "submersible oil bubbler" devised at Quantico, acts similarly to the "dripper" except that the device is completely submerged and the oil comes from below upward. The advantage of this method is that the device is less apt to be interfered with by unauthorized persons and the flow of oil tends to be more uniform and less affected by a change in temperature. These cans are removed and refilled once a week. The container is filled with oil and sunk in the stream of water. The oil, at the rate of 40 to 60 drops per minute, is released and comes to surface, forming a uniform film of oil to destroy the "wiggle-tails" of mosquitoes. (Fig. 142.)

The "oil-soaked sawdust" method of petrolization (also originated at Quantico), affords a simple means of distributing oil over mosquito breeding areas. This method was worked out contemporaneously and independently by the United States Public Health Service. The oil-soaked sawdust is placed in a wire cage or in perforated boxes which are partially embedded in running streams. The cages were found to be effective without renewal of the oil for a period of from 2 to 3 weeks.

Oil-soaked sawdust can be placed in paper bags, which are thrown into marshy vegetation. The bags rupture and liberate the sawdust, the particles of which give a widely distributed film of oil, scattered throughout the aquatic vegetation.

Where there is dense surface vegetation, such as water lilies, the oil-impregnated sawdust may be thrown at random among the vegetation and floatage; each individual particle becomes a means of slowly liberating oil.

The Panama larvicide consists of phenol (carbolic acid), rosin, and caustic soda combined in such a manner that the product has approximately the same specific gravity as water. This larvicide has the advantage over oiling inasmuch as it kills the larvæ of one species, *Mansonia titilans*, which does not come to the surface of the water but gets its air from the roots of water plants. One part of this preparation to 5,000 parts of water will kill larvæ.

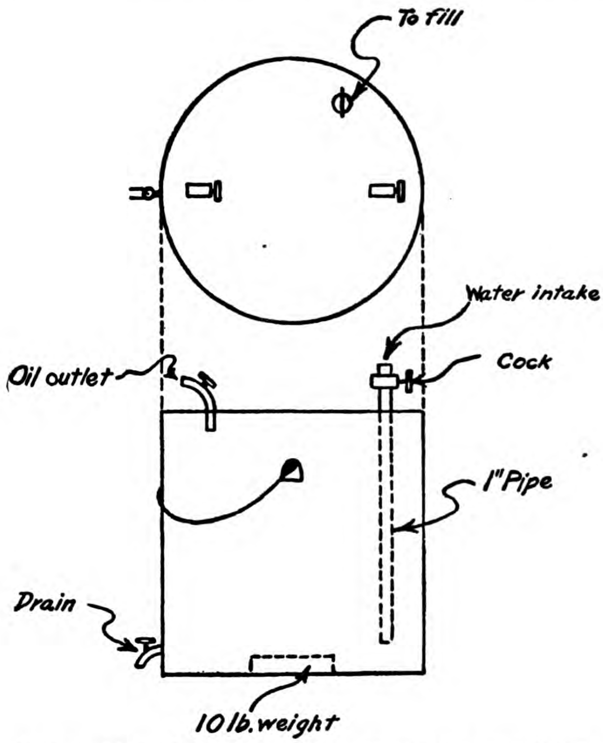

FIGURE 142.—Quantico type of submersible oil bubbler.

Other chemicals, some of which are byproducts in the manufacture of gunpowder, have been employed as larvicides. Arsenic dusting by hand, or airplane, is a more recent development.

Drainage and filling.—Where the mosquito-breeding area is below sea level and cannot be drained, it may be flooded with salt water to prevent breeding. In other undrainable areas deep canalization may be used to reduce the water surface to a minimum, which may then be easily controlled by oiling.

Small swamps and marshes may be filled with dirt, ashes and debris.

A comparatively small amount of stagnant water will furnish sufficient breeding area to infest a small camp with mosquitoes.

A camp located about a mile from mosquito-breeding areas is considered fairly safe from Anopheles. In the selection of a camp site one should endeavor to avoid the proximity of habitations, as these dwellings are apt to harbor mosquitoes and human malaria carriers.

All tin cans, broken bottles, and other receptacles which will retain water should be immediately disposed of to prevent their use as breeding places, and rain barrels and fire barrels should be checked constantly for wiggle-tails. Even the foot prints of horses and men have been found to contain wiggle-tails in regions where water does not evaporate quickly after a rain.

Biological barriers.—It has been demonstrated that Anopheles mosquitoes do not travel far from breeding places if a food supply is close by, which fact may be taken advantage of in the use of "biological barriers." By establishing the corral and stables between the camp site and mosquito-breeding areas the animals provide a source of food for the mosquitoes whose flight in search of food is thereby stopped and the animals act as biological barriers.

Mosquito control by airplane dusting.—This method is advisable when mosquito breeding in large areas of swamps and low, marshy ground must be prevented. The larvicidal mixture commonly used in this way consists of 1 part of Paris green and 4 parts of powdered soap-stone, the mixture being dusted in the proportion of 5 pounds to the acre.

Lice.

Various methods are employed for delousing purposes. "N. C. I." powder, which is considered very efficient in the destruction of lice, consists of the following: Naphthalene, 96 parts; cresosote, 2 parts; iodoform, 2 parts.

This powder is dusted inside of wearing apparel, care being taken to avoid the forks of trousers, as this preparation, if used too freely, is an irritant to the perineal region and may cause a dermatitis. After the use of this mixture the soldier should wrap himself up in a blanket in order to retain the fumes which are generated.

"Vermijelli" is less irritating than N. C. I. powder, and is composed of the following ingredients: Crude mineral oil, 9 parts; soft soap, 5 parts; water, 1 part. This preparation will kill adult lice but has no effect on the eggs.

Clothing may be deloused by immersion in kerosene or gasoline.

Ironing of clothes will kill both the adults and the eggs; steam heat will accomplish the same purpose. The "Serbian barrel" and the "sack disinfestor" are two simple methods of using steam heat in the field.

The Serbian-barrel disinfestor consists of a barrel with a perforated bottom and a tightly fitting removable cover which is weighted down with stones. The barrel is placed over a tank of boiling water; the steam generated from the boiling water flows under pressure into the barrel. The water must be kept boiling at all times while this barrel is in use.

Clothes and other articles may be disinfested by these means. The sack disinfestor depends on the principle that steam entering the upper portion of the inverted bag displaces the air in its course downward and produces an extra atmospheric pressure (about 15 pounds per square inch) which pressure in turn raises the temperature of the interior of the sack to 107° C.

The sack disinfestor is useful for disinfection and disinfestation.

For the destruction of the head louse, acetic acid in 10-per cent solution is applied. Equal parts of kerosene and olive oil are sometimes employed in place of the acetic acid solution. The hair should be combed with a fine-tooth comb.

The methods for the destruction of pubic lice are well known and will not be considered here.

Bedbugs.

There are two species of bedbugs, namely, the *Cimex lectularius* (*Acanthia lectularius*) and the *Cimex rotundata*, the former being the common bedbug

found in the northern climates while the latter is found in the tropical regions.

The eradication of this parasite, especially in the tropical regions, is a very difficult problem.

Fumigation provides very effective extermination. It is a method to be employed primarily in sealed spaces. Carboxide gas is highly recommended. Hydrocyanic-acid gas is equally efficient but should be employed only by personnel skilled in its use.

The blow-torch is effective when applied to the cracks of metal beds.

Kerosene, gasoline, and other chemical insecticides may be poured into crevices to exterminate this pest.

Heating rooms and even entire buildings to a temperature of 120° to 125° F. for several hours will completely eliminate bedbug infestations. Superheating has been resorted to repeatedly with success during hot summer weather when advantage can be taken of the normally prevailing high temperatures. In summer, most home heating equipment is sufficient to raise the temperature of infested rooms to 120° to 125° F., if not higher, without harm to the furnishings. It is well to place thermometers in various parts of the room or rooms in order to note the temperature obtained. The temperature in the cracks where the bugs are secreted must be held as high as 120° F. for several hours. In loosely constructed frame buildings it may not be possible to secure a killing temperature at points close to wall spaces.

Cockroaches.

There are four domesticated species of this family, namely, the Oriental, German, American, and Australian.

Sodium fluoride blown in corners and crevices is a standard poison for this pest. The roaches walk through the powder, some of which adheres to their legs, and are killed by the sodium fluoride when it gets into their mouths, as they clean their legs with their mouths. The use of sodium fluoride is not without danger around a mess hall as it may be mistaken for sodium bicarbonate, baking soda or powdered sugar. Roaches may carry it to food. It is highly toxic to humans.

Another cockroach poison consists of dry plaster of Paris, 1 part, flour, 3 parts. When using the above mixture a dish containing water should be close by. The insect, after feeding upon this preparation, becomes thirsty and seeks water which sets the plaster of Paris and kills by clogging the intestine. Pyrethrum is extensively used as an insecticide for the extermination of cockroaches and other insects. It is incorporated in the Navy issue liquid insecticide.

Fleas.

Pyrethrum powder is effective for removing fleas from the body.

Iodoform and oil of pennyroyal act as repellents.

An emulsion of 5 per cent cresol, with or without soft soap solution (20 per cent), gives excellent results.

Sprinkling a flea-infested floor with flaked naphthalene and closing the room for 24 hours is very effective. A solution of naphthalene in gasoline should be poured into all holes—such as mouse holes—in the treatment of plague-infested houses.

HYGIENE AND SANITATION OF THE MARCH

Military value of marching.

The ability to march has always been—and the results of the World War tend to show that this is still true—one of the determining factors of victory. The superiority in marching ability of troops enables the responsible commander to secure the preponderance of men at the critical time and place. Infantry, in spite of the rapid development of other branches of the military service, is still the dominant arm. To be able to endure long marching requires careful training and attention to a host of trivial details.

According to the Field Service Regulations, United States Army, "Good marching is secured by careful preparation, strict discipline, and observance of march sanitation."

Physics and physiology of the march.

Physics of the march.—A soldier weighing 160 pounds, carrying 40 pounds, and walking 15 miles at the rate of 3 miles per hour on a level surface will perform an amount of work equivalent to 353.57 foot-tons.

According to Haughton, as quoted by Harrington, this labor, in walking over a level surface, is determined by the following formula:

$$\frac{(160a+40b)\times 79{,}200c}{2{,}240d\times 20e}=353.57 \text{ foot-tons.}$$

Key: a=weight of person; b=weight carried; c=distance walked in feet; d=pounds in long ton; e=coefficient of traction.

The coefficient of traction varies for different rates of speed, with the character of the terrain, and wind effect. For 2, 3, 4, and 5 miles per hour, on a level surface, it is approximately 1/26, 1/20, 1/16, and 1/14, respectively.

Physiology of the march.—Compared to the steam engine the human mechanism is a bit more efficient, as the engine is capable of utilizing only 13 per cent of the energy from its fuel for useful work while the human body is able to utilize 20 per cent of the energy value of its diet; the 80 per cent balance goes in the production of heat which must be dissipated in order to keep the body temperature constant.

The unit of energy is the calorie which has been previously explained.

A soldier at rest requires 3,000 calories per day, of which one-fifth (600 calories) actually goes into work, and four-fifths (2,400 calories) is dissipated as heat.

The evaporation of perspiration acts in dissipating heat of the body similar to the radiator of the automobile in maintaining the motor near a constant temperature.

The evaporation of 1 cc of water requires 0.5 calorie, consequently the evaporation of a quart of water—(Imperial measure, 1 quart = 1,182.52 cc)—from the body's surface will dissipate 600 calories of heat.

To produce 350 foot-tons of work, such as in the example of the marching soldier, would require the expenditure of 254 calories as muscular energy. Since the body is only 20 per cent efficient the total expenditure of energy to produce this work would be 1,270 calories, of which 1,016 calories are dissipated as heat. The soldier normally expends 1,000 calories in 8 hours. Therefore, the total caloric need of the soldier during the 8-hour march is 2,270 calories, of which 1,816 calories must be dissipated as heat.

Of the 1,816 calories, 30 per cent is disposed of by radiation, conduction, and convection, while the remaining 70 per cent of the 1,816 calories (equal to nearly 1,300 calories) must be disposed of by evaporation of fluids. As the evapo-

ration of 1 quart of water takes 600 calories, then the total water which must be lost in this 8-hour march is approximately 2 quarts, provided the entire amount evaporates on the body surface.

Effects of water loss:

Miles marched	Quarts perspired	Soldier's condition if water is not replaced	Miles marched	Quarts perspired	Soldier's condition if water is not replaced
7½	1	Habit thirst.	30	4	Danger.
15	2	Thirst of necessity.	45	6	Death.
22	3	Marked inefficiency.			

The physiology of perspiration is vitally connected with heat stroke and heat exhaustion with result from failure to dissipate the excess body heat. As body heat increases due to increasing labor or to increasing accumulation from the environment, a fireroom for example, the function of perspiration becomes of greater importance in keeping body temperature normal. Men should be thoroughly indoctrinated in a few simple facts:

1. Perspiration lowers body temperature only when it evaporates from the surface of the body. Evaporation is retarded when the air is still and has a high degree of humidity. Light, loosely worn clothing promotes evaporation by retaining perspiration on the body surface. Water of perspiration that runs off the body or is wiped off represents a loss and the amount of this loss should be added to the second column of the accompanying table.

2. The body has a comparatively small reserve supply of water and when this reserve is exhausted the body ceases to perspire. As this is the major factor that keeps the body heat normal, heat stroke or heat exhaustion follows. Therefore, water loss should be promptly replaced.

3. Furthermore, ordinary table salt is an essential factor in control of body temperature. The body can neither absorb nor perspire salt-free water. The reserve stock of this salt is limited. When this reserve is exhausted the body will cease to perspire even if the supply of water in the body is ample and it will not absorb water from the intestinal tract even though large quantities are drunk and there is great need for water. This condition of insatiable thirst and diarrhœa can be corrected by adding salt to the water. Prophylactic treatment consists of supplying salt to men perspiring excessively.

Preparation for the march.

It is remarkable to note what improvement in marching ability can be effected in a few weeks of graduated exercise and muscular training. One investigator conducted a series of experiments on an untrained man marching a certain distance in a given time with the following results:

	Untrained soldier	After 3 weeks' training
Increase in pulse beats	72	28
Increase in temperature, °F	2.2	0.6
Loss of weight — pounds	2¾	2¾

Men should be trained in marching by increasing the length of the hike and the weight of the pack. They should be so trained for several months. This training means the development of all muscles in the body—an increase

of capacity of the lungs and heart, also strengthening of the foot arches, and the like. It is at this time that the medical officer should keep close supervision over the men. Overtraining defeats the purpose and leads to cardiac dilatation and eventually to exhaustion.

Men under training should be given periods of mental and physical relaxation and recuperation. It is remarkable how quickly the human mechanism develops with progressive and systematic exercises. The raw recruit under proper supervision shows rapid development within a few weeks of training.

The men should be trained to breathe through the nostrils, as in this way dust and other foreign bodies are removed from the air before it reaches the lungs, and the air is warmed. Mouth breathing tends to dry the mouth and thus increase the sensation of thirst.

A person marching at the rate of 4 miles per hour inhales five times as much air as when reclining.

Conduct of the march.

The most suitable time to start a day's march is 1 hour after the break of day. Night marching should be practiced only when military necessity demands, and then should begin soon after sunset.

The canteens should be filled preferably the night before the march. The sick and the physically unfit should be eliminated at the morning sick call. By all means avoid premature assembly of the men—get them "under way" as soon as practicable after "falling in." A light breakfast should be served.

The sanitary officer, with a police detail, remains for a few minutes after the camp is cleared to see that all waste and litter are disposed of, latrines filled in and labeled, and that the camp site is otherwise left in a clean and sanitary condition.

Rate of march.—The human mechanism—similar to the automobile motor—must be warmed up before it can function at its best in marching.

The physiologically best temperature for the body in marching is 100.5° F. and 102° F. is the maximum temperature before serious symptoms become noticeable, such as swaying, tremor, nervousness, etc. Thus there is only 1.5 degrees range between the optimum body temperature and danger body temperature "and this narrow safety margin indicates alike the delicacy of the adjustment mechanism and the importance of every means of aiding that adjustment."

A horseman always starts his horse off slowly, and the end of the ride is made at a slow pace. Likewise the infantry leader should start his men off slowly so as to warm up, and the last few minutes should be at a slow pace for the men to cool off. Always avoid the tendency to the final spurt in nearing evening camp.

The ordinary Marine Corps shirt holds a pint of perspiration, when saturated, this is equivalent to 300 calories, which energy can be conserved by the simple expedient of slow marching at the end of the day. This permits the moisture to be evaporated on the body during the marching period when the cooling effect serves a useful purpose. The march should be completed with a nearly dry shirt to prevent a harmful chilling effect during the following rest and recovery period.

The rate for infantry is 100 yards per minute. To maintain this speed, one hundred and twenty 30-inch steps are required, which gives an actual rate of 3.46 miles per hour (exclusive of rest periods). This may be regarded as the

most economical speed for experienced troops. For unseasoned troops and for longer hikes, the economical speed is a slower cadence.

With a speed of 3.46 miles per hour for the day's march, if the rest periods are included, from start to end of the march an average of 2½ miles per hour is considered the maximum expected of foot troops.

Double time is a 36-inch step at the rate of 180 steps per minute, and should never be used in routine marching.

In route step, there is no standard stride or cadence, and the men are out of step, which is often a restful variation.

The marching column varies with route step, marching in time, and marching to music or singing.

Mechanics of marching.—Mathematical calculations show that in marching the best mechanical advantage is obtained by a stride the length of which is six-sevenths the length of the leg. The stride is a pendulum motion.

The correct position for head and limbs in marching corresponds to the attitude one assumes when about to ascend a flight of stairs.

The proper load for an infantryman should not exceed one-third of the body weight, or 50 pounds for a 150-pound man. The maximum is 45 per cent of body weight or 67 pounds for the average man, and any increase above this 67 pounds causes expenditure of energy to be increased three times as rapidly as the weight of the load.

The load should be adjusted near the center of gravity of the body, i. e., in the erect position 0.6 cm in front of the line connecting the femoral heads and opposite the center of the third lumbar vertebra.

The chest or abdomen should not be constricted by the load and the load should be borne by the shoulders and back.

March formation.—If there is much traffic on the road the marching column should keep to the right and proceed in squad formation. If circumstances permit, it is much better to march in open ranks, half on each side of the road, which order tends to decrease the heavy oppressive cloud of dust, foul odor, and water vapor from perspiration which tend to hang over close-order formation.

The taller men at the head of the column are apt to set a pace uncomfortable to the shorter men marching in the rear of the column, and it is also easier marching at the head than in the rear, consequently the column should be reversed from time to time. The rear files as a rule expend about 6 per cent more energy than those at the head.

Halts.—The first halt should be after 30 minutes of hiking, and should be for a period of 12 minutes. The object of the first halt is to permit the men to get their "second wind," adjust shoe laces, rearrange packs, and to attend to the calls of nature. The succeeding halts are made every 50 minutes and are for a period of 10 minutes rest, except for the halt for the noon meal, which is for 1 hour.

During the rest periods the men should remove their packs and lie upon their backs. Their coats should be replaced and unbuttoned to avoid undue exposure to drafts and winds. An endeavor should be made to halt in cool, shady places, protected from strong winds. A place should be provided for the men to attend to the calls of nature during the rest periods—shallow trenches dug with a bayonet or sharp stick will suffice for this purpose.

Endeavor to select locations for halts that have the following characteristics: Clean and dry; sheltered from the sun; and privacy.

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If practicable avoid halting the column in towns, villages, or near habitations.

Massage and kneading of the muscles of the legs during halts helps free them of accumulated waste products and prevent stiffness.

In difficult and mountainous country the halt periods should be more frequent.

The order should be given to "remove packs" within 30 seconds after a halt—any unnecessary delay irks and irritates the marching organization.

Length of march.—The length of the day's march is not measured by miles, but according to the condition of the roads, the weather, the pace, the weight of the loads, experience and physical condition of the troops, etc.

	Miles per day
Average for large body of infantry	12
Average for small body of infantry	15

Any distance beyond the above is regarded as a forced march.

Wagon trains march about as rapidly as foot troops.

Artillery covers 15 to 20 miles per day.

Morale.—A fatigued body causes a hypersensitive state of mind, which is more susceptible to real or imaginary adverse stimuli. To inhibit the action of these stimuli calls for resourcefulness and leadership in company officers. One company under proper leadership will arrive in the evening camp, tired, but happy, whereas another company, not so fortunate in the selection of company officers, is apt to come into camp tired and dissatisfied.

Singing and whistling of popular tunes should be encouraged, as this distracts the minds of the men from their fatigued state, and is one of the surest means of preventing them from succumbing to exhaustion.

Straggling, either from poor discipline or fatigue, is always to be avoided, as it is depressing to the morale of the entire body of troops.

Night marching.—Marching at night should be permitted only for strong tactical reasons, as marching at this time interferes with the sleep routine; in the darkness men cannot be sure of their footing and accidents may occur.

Marching in the tropics.—In warm countries the march should be started earlier, shortly after daybreak, if practicable. Marching in the middle of the day should be avoided by a midday rest period of 2 to 3 hours.

Green leaves or a wet handkerchief in the hat serve to protect the head and neck from the sun's rays.

It is particularly necessary to open up shirt fronts and roll up the sleeves. Tests with a dry and wet bulb reading 79° F. and 67° F. were conducted on an organization hiking 7 miles and the men were found to lose an average of 3 pints of water. But with shirts opened and sleeves rolled up the loss of fluid was reduced from 3 pints to 2 pints in marching the same distance under the same climatic conditions.

In warm countries the loss of heat by radiation is generally very rapid after sunset, consequently a fall in body temperature and a chill results if the men are wet with perspiration and not given time to cool off gradually before halting for the night.

An endeavor should be made to detect early appearance of symptoms of heat stroke which frequently occurs during hot weather marches.

The treatment is:

1. Loosen all clothing.
2. Remove patient to shade.
3. Strip to waist.

4. Fan patient.
5. Apply ice bag or cold water freely to head, neck, and spine, and continue until symptoms subside.
6. Restore body chlorides by administering salt.

Water discipline on the march.

In marching 1 mile a fully equipped soldier generates 90 calories which will require the evaporation of 180 cc of water to dissipate the heat. For 3 miles, or 1 hour of hiking, he will require 540 cc of water, which is a little over one pint (473 cc) and for 2 hours of hiking the soldier will lose 2 pints or the equivalent of one canteen of water.

In interpretation of the above, it must be remembered that the water requirements are based upon the climate of middle and western Europe. In a hotter and drier climate, a larger amount of water should be used.

There are so many factors entering into the water requirements that any attempt to be dogmatic or standardize the fluid intake for the marching soldier is apt to result in more damage than good, if a standard is too rigidly adhered to. It is safe, however, to use the following as a guide, since the soldier starts the march with about 1 pint of extra fluid in his stomach: Drink 1 pint, half the contents of the canteen, for each hour of marching, including rest periods, the marcher to take the first drink at the end of the second hour after leaving camp.

The following table shows how the water requirements of a man on a day's march may be met:

Start of march	First hour	Second hour	Third hour	Fourth and fifth hours	Sixth hour	Seventh hour	Eighth hour	Ninth hour
Leave with 1 pint in stomach.	--------	Drink ½ canteenful.	Drink remaining ½ canteenful.	Noon rest. Refill canteen. Leave with 1 pint in stomach.	--------	Drink ½ canteenful.	Drink remaining ½ canteenful.	Camp. Refill canteen.

As the hot climate of the tropics considerably increases the water demands of the infantryman, the above must be increased; hilly, muddy, and rough roads also increase water demands.

The canteen should be used only during the rest period and then upon command. Water should be slowly sipped as thirst is quenched better. In addition to water consumed from canteens, a pint or more is consumed with each meal.

The experienced soldier has instinctively determined the proper amount of water which his system will require; it is the raw recruit who is apt to "water log" his tissues, sweat profusely, and tire easily.

One type of thirst is due to dryness of the mouth, and to overcome this factor the men are advised to chew gum, or keep pebbles in their mouths, which promote the flow of saliva and tend to allay this form of thirst. Smoking on the march tends to increase thirst and should be limited to rest periods, or, as some authorities recommend, should be prohibited during the march.

As a rule marching troops are accompanied by water carts containing potable water. It is most important that only pure water be used in the canteens, as the stomach of a marching soldier is apt to contain insufficient hydrochloric acid to destroy infective organisms.

The water needs of officers are slightly less than those of men, because their equipment is lighter, and marching to one side requires less work than marching in ranks.

Immediately after arriving in camp guards are posted over the water supply which is marked to show the use to be made of different portions of the running stream. A white flag indicates the portion farthest upstream to be used for drinking water; a blue flag, next downstream, the portion for watering animals; and a red flag, farthest downstream, the portion for bathing and washing clothes.

Food on the march.

A light breakfast consisting of oatmeal, tea or coffee, bread and jam, and perhaps some bacon to "stick to the ribs", should be served before beginning a march. The food should be easily digestible. A heavy breakfast is inadvisable as digestion is interfered with by the vascular demands of muscles used in marching.

Exhaustion retards digestion so that it is well to have a brief interval of rest just before the noon and evening meals. The noonday meal should also be light and digestible, and should be served during the noon rest period.

Upon arrival in camp for the evening, serving soup ahead of the meal increases the digestive capacity 20 per cent, owing to the stimulation of the flow of gastric juices. The main meal should be the evening meal.

Slowly-cooked stew increases the digestibility of proteins.

Foods with high-vitamin content such as fruits, vegetables, or even canned tomatoes should be served, because the individual soldier in the field does not have the opportunity of supplementing his ration by outside purchases of food.

In view of its rapidity of digestion and oxidation, *sugar* is the quickest restorative of muscular energy. A marching man craves sweets, candies, jams, preserves, and sweetened coffee or tea. Chocolate or cocoa are excellent for restoring muscular tone.

The following table furnishes data for use as a basis for calculating the food requirement of the marching man:

	Calories	Foot tons of energy
1 gm. protein furnishes	4.1	6.3
1 gm. fat furnishes	9.3	14.2
1 gm. carbohydrate furnishes	4.1	6.3

When marching at the rate of 3 miles per hour the soldier does work the equivalent to raising one-twentieth part of the weight of the body through the distance he walked.

	Work in tons lifted 1 foot
Marching 1 mile	18.86
Marching 2 miles	37.72
Marching 10 miles	188.60
Marching 20 miles	377.20

If the soldier carries 60 pounds of equipment, the foot-tons are increased 30 per cent. Carrying 60 pounds and marching 20 miles the soldier expends the equivalent to 518.60 foot-tons.

Manifestly the caloric requirement of a soldier when marching is higher than when at rest. A diet of 4,000 to 6,000 calories should be planned, depending on the length of the marches, rate, condition of road, terrain, weight of load carried, and other influencing factors.

The use of tobacco and alcohol by marching troops has proponents and opponents. Smoking should be limited to rest periods. Alcoholic beverages should be restricted to the evening after arrival in camp and temperance must be enforced.

March sanitation.

Sanitary measures to be carried out while on a march are as follows:

At the start.—1. Fill and chlorinate water carts; canteens should be filled the night before; 2. Police camp, extinguish camp fires; 3. Fill in, close, and mark latrines; 4. Sanitary officer and police detail remain and clear up waste and litter; and 5. Final inspection of camp site.

At a halt.—1. Designate sanitary area; 2. Dig shallow pits for calls of nature, using bayonet or stick for digging implement; and 3. Refill canteens.

Selection of camp site.—Toward the end of the day's march a staff officer, a medical officer, and an engineer officer or a quartermaster should ride forward and select a camp site, unless this has been previously arranged. The functions of the medical officer are advisory in the final selection of the camp site. In time of war tactical consideration is of primary importance in the selection of a camp site. It is impracticable to locate an ideal camp site which will be entirely satisfactory from a medical viewpoint, hence the medical officer must consider the pros and cons of the available locations. Favorable consideration should be given the following characteristics:

(*a*) Accessibility to a supply of good water, fuel, and forage.
(*b*) Sandy loam or gravel soil.
(*c*) Elevated site well drained, such as sloping plateau.
(*d*) Shade trees as a protection from the sun's rays in warm weather.
(*e*) Hills and forests acting as windbreaks in cold weather.
(*f*) Location large enough to accommodate the troops without crowding.
(*g*) Grass-covered location.

Unfavorable consideration should be given to:

(*a*) Sites recently occupied by other troops, allowing 2 months' vacancy before reuse as an arbitrary standard.
(*b*) Dry bed of river, ravines, and base of hills if there is likelihood of rain.
(*c*) Clay, alluvial, or dusty soil.
(*d*) Proximity to marshes, swamps, and other mosquito-breeding areas.
(*e*) Steep slopes.
(*f*) Sites where the ground water is near the surface.
(*g*) Proximity to native habitations especially in malarial regions.

In camp.—1. Proper waste disposal; 2. Insect control; 3. Water inspection; 4. Food inspection; 5. Care of the feet; 6. Do not keep troops waiting in ranks after arrival at destination; and 7. Water responsibility: Its purity—medical officer; quantity and delivery—engineer officer; procurement—quartermaster; and water guards and distribution—Unit commander.

Always remember that *today's camp site may be tomorrow's line of communication.*

MEDICAL DEPARTMENT ON THE MARCH

Before starting, the responsible surgeon should see that all sick and unfit are eliminated, that the camp site is left in a sanitary condition, that the quality of water in the canteens is satisfactory, and that foot disorders have been given the requisite attention.

The *brigade surgeon* proceeds forward on the staff of the brigade commander.

The *regimental surgeon* occupies a corresponding place in the regiment to that of the brigade surgeon, and the assistant regimental surgeon marches in the rear of the headquarters company.

The *battalion surgeon* proceeds with the staff of the battalion commander, and the *assistant battalion surgeon* marches in the rear of the battalion. If there is only one surgeon assigned to a battalion, he should march in the rear of the unit.

The *junior medical officers* marching in the rear should occasionally proceed up and down the marching column of their respective organizations to observe the condition of the troops.

Soldiers suffering from the effects of fatigue may be dropped at the march collecting stations, ride in ambulances, or they may be allowed to proceed without their equipment—their equipment may be thrown upon one of the wagons of the train. All sick and injured patients should be properly tagged with the diagnosis tag and recorded. A compilation of these records is made at the end of the day's march.

The *medical battalion* proceeds in two groups—one, consisting of the mounted and foot group, marching in advance of the animal-drawn train, and the other, consisting of the motor-drawn group, proceeding at the head of the motorized train of the brigade.

If the marching command is composed of a brigade or larger organization, it is advisable to establish *march collecting stations* every 3 miles. The personnel for these stations consists of two or more hospital corpsmen, who are equipped to give first-aid treatment to the sick, injured, and exhausted, and to retain the patients until they are picked up by the ambulances in the rear of the column.

The hospital corpsmen detailed for the purpose of establishing march collecting stations should proceed with the head of the column or advance party and drop off every 3 miles to form collecting stations. They remain until the tail of the column has cleared their station, then fall in with the rear units.

Toward the end of the day's march the necessary sanitary personnel should join the advance guard to supervise water purification and make arrangements for sanitation before the main body arrives.

Combatant units of advance guards, rear guards, and other security detachments are normally accompanied by their attached medical troops.

In view of the fact that *poison ivy* is a source of danger to a marching command, detailed consideration is advisable. (*See* Contact Dermatitis, p. 481.)

Ivy poisoning is a form of dermatitis venenata due to exposure to poison ivy (***Rhus toxicodendron***), and the excitant is an oily compound called toxicodendrol, belonging to the phenol group. As little of 0.001 mgm. of toxicodendrol may produce dermatitis. All parts of poison ivy contain the irritating principle, the leaf especially.

Poison ivy grows as a woody vine, trailing shrub, or erect bush, growing in the woods or in the open, in moist or dry soil. It climbs trees and posts.

The plant is recognized by its leaves which are divided into three leaflets, and by its white mistletoe berries, known as drupes; the latter remain on the

plants into winter after the leaves have fallen. All of these plants do not bear the drupes and it must be recognized by the leaves.

The leaves are from 1 to 4 inches long. The end leaflet of the triad has a longer stem than the two opposite leaflets, which, as the leaves are broad, though pointed, preserves the symmetry of the arrangement.

The mature leaves are dark green on the upper surface and lighter underneath. The crinkly young leaves are red when they first unfold, becoming green later. In autumn they turn to beautiful shades of scarlet and orange. The innocent sometimes pluck these leaves and to their sorrow bear them off. The old adage: "Leaflets three, let it be," is a safe rule for those who are not familiar with poison ivy to follow.

The period of incubation, after contact by the susceptible, is usually a few hours but may be delayed for days. Redness and erythema appear, usually first on the face and hands. Shortly, fine vesicles, clear and closely grouped, are observed in the thinner areas, such as the inner surface of the fingers. Other areas of the skin become affected, even those where there has been no direct contact. The eyelids and surrounding tissues are frequently greatly swollen. Probably by indirect contact the genitals become œdematous and the rash has a predilection for the looser and thinner skin.

As the active agent is fat and alcohol soluble, the irritant may be largely removed if immediately after exposure the areas are washed with soap and water. Alcohol or ether, used on swabs, being careful to clean the irritated areas from the periphery towards the center, is a more effective measure.

Two readily available agents are recommended for the treatment of the lesions.

1. Potassium permanganate in a 5 per cent solution in water, applied locally by cotton swabs or cloths; frequent applications should be made, or if a dressing is used, frequent changes of the dressing.

2. Chloride of iron, a 5 per cent solution in equal parts of alcohol and water can be used in the same way.

THE FOOT

Anatomy and physiology.

The human foot is a specialized organ designed to promote terrestial locomotion of the individual by leverage action of the foot in lifting the body's weight and it plays such a dominant role in marching that a brief description is appropriate.

Considered in its entirety, the human foot is indeed a very wonderful anatomic part of the individual. In the smallness of its size and weight, out of all proportion to the burden borne and carried, it constitutes a mobile, strong, flexible, and efficient member of the organism designed to bear weight forwards, backwards, and sideways without mishap. Encased in a cloth covering, the sock, and in a protective leather covering, the shoe, both concomitants of an advancing and exacting civilization, this member, the most unintentionally neglected part of the body, is expected to do its full duty.

The foot is composed of a nicely adjusted aggregation of 26 bones of various sizes and shapes, each, however, designed to perform a certain definite function. Seven of these are of a very irregular shape and are located in the hind part of the structure forming the heel and a portion of the so-called instep. The remaining 19, situated in the forepart of the foot, form a portion of and radiate fan-like from the instep. These extend forward and to the outer and inner sides, finally ending in the toes. These different bones are held together in a correct position by ligaments, tendons, and muscles; the ligamen-

tous support predominating in the posterior 7 bones which form the static portion of the foot, while muscular action predominates in the anterior 19 bones which form the dynamic portion. (Fig. 143.)

The posterior seven bones, forming a compact mass held by ligamentous attachments, move very slightly when a step is taken and serve to minimize the shock of impact and act as a recoil mechanism. On this mass—the static portion of the foot—in the shod man, all the weight of locomotion is first borne; first affecting the heel and center of the instep.

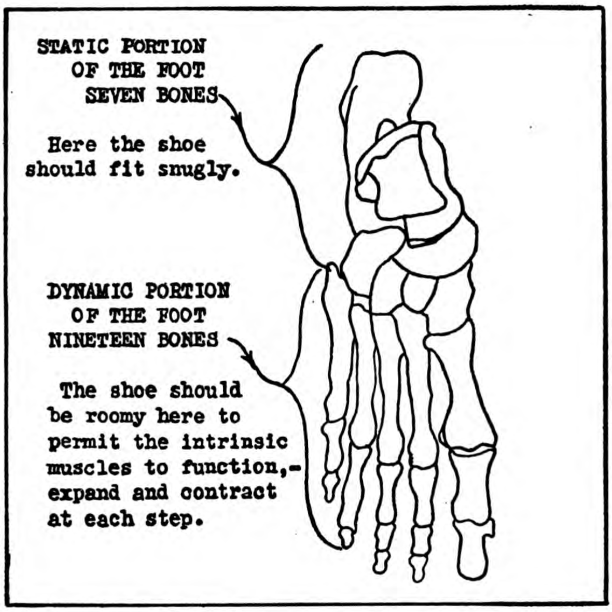

FIGURE 143.—Bones of the foot.

As mentioned under the Mechanics of Marching, the center of gravity of the body must be considered in the carrying of extra equipment. When the soldier is standing, stance, stable, or static equilibrium is involved as the center of gravity is directly above the feet which act as a support.

When locomotion is started as in marching, dynamic equilibrium is brought into force by an active interplay between the organic energy of the soldier and the force of gravity. The feet function as a series of levers that act against the body's center. In marching the body's center is constantly being displaced forward and gravity thus assists the forward translational motion through its influence upon the unbalanced body weight. The walking man, so to speak, tends to fall forward at each step, until this action is interrupted temporarily and the body is balanced momentarily by one foot as a support. The marching soldier always has one foot on the ground.

Man, more often than any other animal, in upright bipedism, makes better use of gravity as an auxiliary force in locomotion.

Care of the feet.

It is difficult to overemphasize the value of the proper care of the feet. It is said that during the first days of a campaign 10 to 25 per cent of the men are physically disabled from foot troubles. Of course the prevention of the foot injury while marching depends upon properly fitting shoes and socks.

Shoes.—According to the Duke of Wellington, the three most important parts of a soldier's equipment are a pair of good shoes, a second pair of good shoes, and a pair of half soles.

A common mistake of the recruit is to call for the same size shoe worn in civil life. With the noticeable difference in the last of the military shoe, especially its width, the man will receive a shoe perhaps three or four sizes too short, and in a few weeks will develop some form of sore feet. To obviate these common mistakes the feet must be measured by an officer, the man must

wear his full equipment to cause full expansion of the feet, and the inner surface of the shoe must be a quarter of an inch longer and wider than the foot.

New shoes should not be worn on the march unless they have been broken in. An excellent method of adapting new shoes to the foot consists in the soldier standing in his shoes in 2 inches of water for 5 minutes. This makes the leather soft and pliable. The man then walks on level surface about an hour, and the pressure of the body weight causes the drying leather to conform to the shape of the feet. This scheme accomplishes in an hour what a week of ordinary "breaking in" can produce.

Socks.—It is equally imperative to wear properly fitting socks, and the proper sizes to be worn with the required length of shoe are given in the sub-joined table.

Light woolen socks in summer time, and heavy woolen ones in winter, are preferable over cotton fabric.

Socks too large will form folds and thus cause pressure foot injuries and if too small tend to produce ingrowing toenails, hallux valgus, and clubbed toes.

Turning socks wrong side outwards, and changing socks from one foot to another equalizes wear, and is conducive to comfort. Holes in socks are apt to cause blisters as the edges of the hole tend to curl and cause pressure damage upon the subjacent skin area. Avoid using darned socks.

The life of a good light-wool sock is about 100 road miles, but if feet are wet the sock will wear through much sooner.

Socks colored with aniline or other irritating dyes which wash out with perspiration should not be worn; gray or white being preferable.

Ribbed socks are better than plain ones, as they are more elastic and fit the foot better.

Shoe Size:	*Corresponding sock size*
5–5½	10
6–6½–7	10½
7½–8–8½	11
9–9½–10	11½
10½–11–11½	12
12–12½–13	12½
13½–14–14½	13
15	13½

Some soldiers grease their socks or rub the feet with candle, vaseline, or unsalted pork, and thus lessen the friction between foot and sock.

New socks should be washed and shrunk before use for marching purposes.

Feet.—It is also essential to keep the feet clean, to prevent abrasions and infections. The feet must be washed daily at the end of the march, clean socks should replace the dirty ones, which should be washed and dried overnight. If water is not abundant the feet can be cleaned by wiping them, particularly the toes, with a wet cloth. The following routine upon arrival in camp is recommended:

1. Remove shoes, clean, dry, and dub them.
2. Wash feet in cold water to tone foot muscles. Foot inspection by company commanders.
3. If feet are tender bathe in alcohol or 1 per cent formaldehyde solution, or 2 per cent alcoholic solution of salicylic acid, or 1 per cent picric acid solution.
4. Put on clean socks and shoes.
5. Wash and knead soiled socks for use next day.

6. Trim toenails square, so as to prevent ingrowing toenails. Another method of prevention of ingrowing toenails consists of scraping the upper surface of the toenail in center. This causes the nail to be thinner in center and leads to eversion of the outer sides of the growing nail. This method is claimed to be an effective prophylaxis.

Treatment of foot disorders.—Puncture blisters at dependent portions of base, using sterile needle, remove serum, and paint with tincture of iodine. Cover blister with adhesive tape with small hole in center to allow discharge to escape.

For smelly feet (bromidrosis) use 2 per cent solution of formaldehyde or apply 2 per cent salicylic acid ointment.

An old custom of the soldier to lessen friction between socks and foot is to soap the inside of the sock; with the perspiration of the foot the soap becomes a lather which serves as a lubricant. Another means of minimizing the rubbing of the foot by the shoe is to wear 2 socks on each foot.

In cold weather, when the feet perspire less, friction may be minimized by dusting foot powder inside the sock. This foot powder consists of:

	Parts
Talcum (Magnesium silicate)	87
Boric acid	10
Salicylic acid	3

Chafing between the toes is cured easily by cleanliness, a small wedge of cotton separating the toes, and the application of the foot powder. Corns are treated by salicylic acid collodion or ointment applied nightly after a hot foot bath; usually after four or six applications the corn easily can be removed with curved scissors. Corn collodion consists of:

Salicylic acid	grains	60
Extract of Cannabis indica	do	8
Flexible collodion	ounce	1

To preserve this mixture a small amount of alcohol may be added.

Corn salve consists of:

	Parts
Salicylic acid	40
Vaseline	30
Lanolin	30

In some experienced organizations, sore feet are reckoned as a military offense both for the individual and for his company commander. Careful attention to the feet of marching men is as important as the attention bestowed on the rifle, and many foot troubles can be eliminated by the rules described.

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Section 7.—DUTY WITH MARINE CORPS EXPEDITIONARY FORCES

The hospital corpsman serving with Marines has many and varied duties. He becomes primarily a soldier and may be detailed with the medical detachment of the combat units; as a nurse in the hospital section of the medical company; a clerk in the headquarters section; or as a litter bearer in the

collecting section. He must be physically robust and capable of quickly adapting himself to all the conditions of a soldier's life.

The act of August 29, 1916, provides, in part, as follows: "Officers and enlisted men of the Medical Department of the Navy, serving with a body of Marines detached for service with the Army in accordance with the provisions of section sixteen hundred and twenty-one of the Revised Statutes, shall, while so serving, be subject to the rules and articles of war prescribed for the government of the Army in the same manner as the officers and men of the Marine Corps while so serving."

The responsibility and functions of the medical department with Marines may be summarized as: The conservation of the fighting strength of the force.

This is accomplished by:

(*a*) Supervision of sanitation and hygiene.
(*b*) Prevention of epidemics.
(*c*) Management of epidemics when they occur.
(*d*) Collection, evacuation, and hospitalization of the sick, injured, and wounded.
(*e*) Prompt return of sick and wounded to their organization, and elimination of the permanently unfit.
(*f*) Procurement, storage, and distribution of medical supplies.

The medical department of a Marine Corps post is organized as follows:

1. An administrative headquarters, or post surgeon's office with the following duties:

(*a*) Coordination of all the medical activities.
(*b*) Preparation and forwarding of all medical department reports and returns.
(*c*) Preservation of medical department files.
(*d*) Procurement, stowage, and issue of medical supplies.

The post surgeon is the advisor to the commanding general on all matters pertaining to sanitation and the health of the post.

2. The sanitary inspector has the following duties:

(*A*) Supervision of the sanitation of the post.
(*B*) Preparation of data and charts relative to—

(*a*) Sick rate.
(*b*) Incidence of venereal disease.
(*c*) Epidemics.
(*d*) Sanitary work contemplated or undertaken.
(*e*) Disease carriers.
(*f*) Food.
(*g*) Water.
(*h*) Epidemiology.

(*C*) Maintenance of contact with local civil health authorities.

3. Dispensaries maintained in each brigade area with a medical officer in charge who keeps health records of brigade personnel; provides temporary care of the sick and injured; instructs his subordinates in first aid; advises the brigade commander on matters affecting the health of the organization and instructs the brigade personnel in personal hygiene and first aid.

4. A sick quarters maintained to furnish hospital treatment for the sick and injured and similar to a naval hospital in organization.

THE FLEET MARINE FORCE

The Fleet Marine Force is a highly mobile body of troops composed of infantry, artillery, engineers, and aviation groups, created for employment as a component unit of the United States Fleet and kept in the same state of readiness as the other units of the fleet. This force is divided into two brigades. The first is stationed at Quantico, Va., and the second at San Diego, Calif. For purposes of training it operates directly under the Commander-in-Chief, U. S. Fleet and accompanies the fleet on the annual fleet problems. It constitutes the force which is ready at all times to go on expeditionary duty. The organization and functions of the medical department of the force on expeditionary duty are outlined briefly in the following paragraphs.

ORGANIZATION OF MEDICAL DEPARTMENT WITH A MARINE EXPEDITIONARY FORCE OF ABOUT THE STRENGTH OF ONE INFANTRY BRIGADE WITH ATTACHED ARTILLERY, ENGINEER, AIR SERVICE, AND OTHER SPECIAL TROOPS

The whole medical department is under the control of the force surgeon who is responsible for the sanitation of the occupied area; the collection, evacuation, and hospitalization of all sick and wounded; preparation of reports, records, and returns; procurement, storage, and distribution of medical and surgical stores; training and coordination of all the medical units of the force.

For convenience the organization may be shown by briefly considering the various medical units from the front to the rear beginning with that of the infantry regiment (fig. 144).

The medical section of an infantry regiment is composed of a regimental surgeon, assistant regimental surgeon, dental officer, and 9 hospital corpsmen. For each of the 3 battalions of the infantry regiment there is a medical section composed of 2 medical officers and 16 hospital corpsmen. The hospital corpsmen of each battalion may be assigned duties as company-aid men, litter bearers, or aid-station men.

In combat the regimental medical section is concerned with furnishing medical supplies to the battalions, reports and returns, sanitation of the area and coordination of the evacuation of wounded and sick from the regimental area. Regimental aid stations are not established unless the regiment is acting independently or the military situation requires their participation.

The battalion medical section furnishes first aid to and transportation to aid stations for the wounded, and provides for their temporary care until they can be evacuated. With this object in view, aid stations usually are established behind each battalion. The hospital corpsmen serving as company-aid men go forward with their companies and apply first-aid dressings to the wounded. If the whole force is advancing rapidly, the aid stations are not established until the situation becomes somewhat more stationary, and the wounded who have been given first aid are left in groups to be evacuated by other medical units following.

After the company-aid man has completed his initial task of applying first aid, he directs the slightly wounded to the aid stations and the litter bearers transport the nonambulant cases.

At the aid stations they are given supplementary first aid, hæmorrhage is controlled, shock is combated, pain is relieved, tetanus antitoxin administered, fractures are immobilized with field splints, slightly wounded are treated and returned to their units at the front while those requiring evacuation are sorted,

tagged, and recorded. Wounded able to walk are directed to the collecting station, others are carried thereto by litter bearers from the rear.

The aid stations are established as close to the front as the situation permits, taking advantage of any available shelter from rifle and artillery fire, such as dugouts, ravines, and deserted cellars. These places of course should be avoided in the presence of enemy gas.

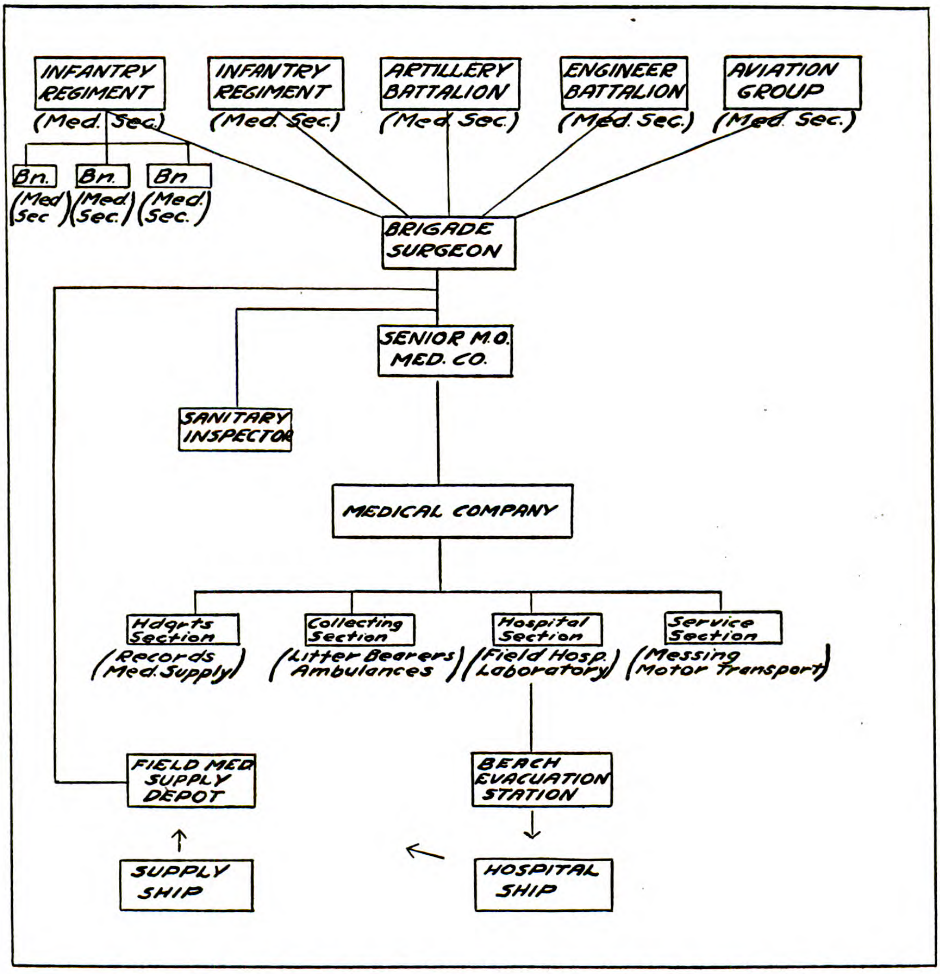

FIGURE 144.—Organization of medical department for one brigade, Fleet Marine Force.

As the functions of the battalion-aid station require it to keep close contact with its battalion it must keep as clear of wounded as possible at all times.

During combat the battalion-medical section covers the whole area occupied by its organization, from the aid station forward to the battle line. It is essential that all its activities be confined to this area and that its efforts be coordinated by the regimental surgeon, who is informed from time to time by runners or other means of communication from the battalion-aid station, of any change in their location. The battalion surgeon keeps contact with the medical units in his rear by means of a contact agent from the collecting station, who directs the litter bearers forward to the aid station. Routes to aid stations may be shown by some means such as hanging pieces of bandage at intervals

along the route. Their location should be shown to those in the rear by indicating their map position.

Dispensary service is established in the regiment when not in combat.

The regimental and battalion medical sections are called attached medical troops because each section is part of the headquarters company of its respective organization.

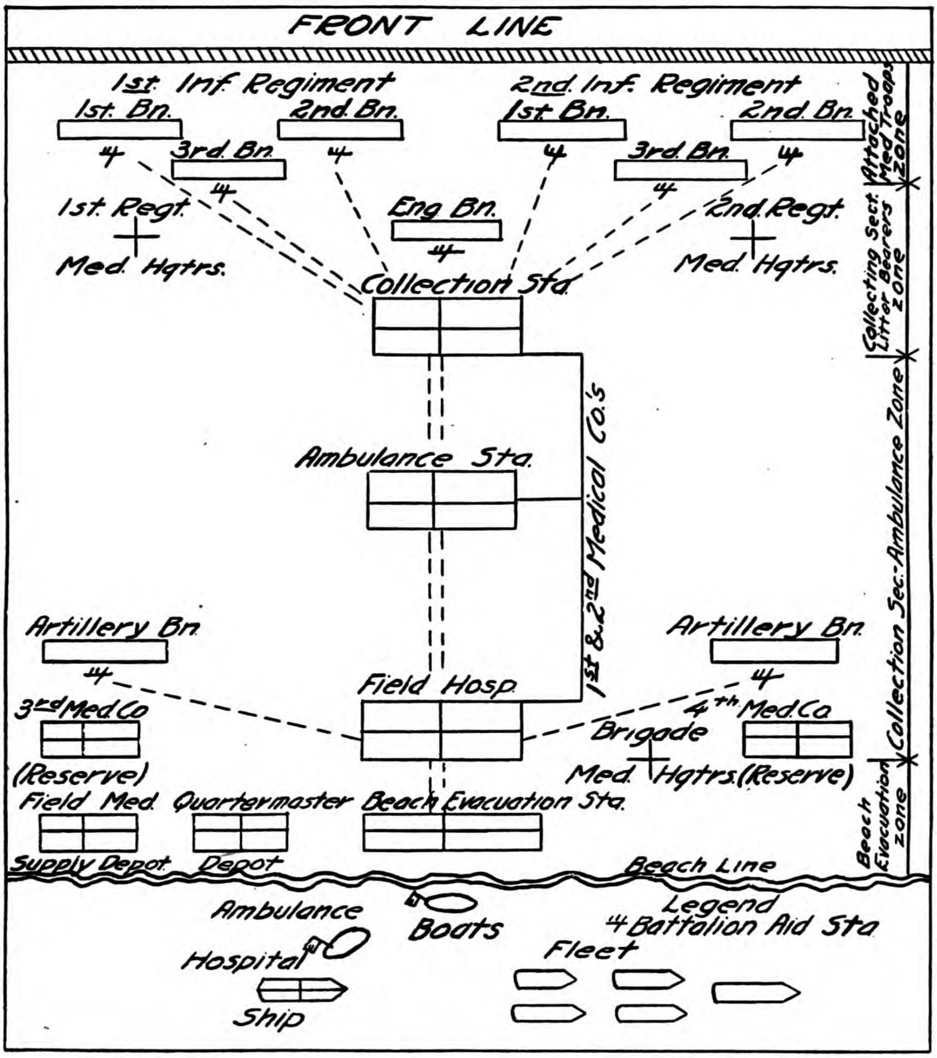

FIGURE 145.—Schematic distribution of medical department units with a Marine brigade, Fleet Marine Force, in a landing operation.

Behind the attached medical troops is the medical company.

There are four medical companies attached to each brigade (fig. 145). A medical company consists of a headquarters section, a collecting section, a hospital section, and a service section. It is a highly mobile unit whose chief functions are the collection of the wounded and sick from the battalion-aid stations and the further evacuation of these casualties to a hospital ship or evacuation hospital. Temporary hospitalization is provided as required by the individual case and by the military situation. Secondary functions are the keep-

ing of records and the requisitioning of medical and quartermaster supplies and the distribution of the same.

The headquarters section is divided into staff (administration, personnel, and records) and medical supply (materiél and storeroom). The service section consists of mechanics, electricians, cooks, supply and commissary personnel, and drivers for the ambulances and trucks of the company. Storage, lighting, and water trailers complete the rolling equipment of the company.

The medical company forms the relay for evacuation of all wounded and sick from front to rear by establishing collecting stations, ambulance stations, hospital stations, and beach-evacuation stations.

In combat the collecting-section group establishes a collecting station at a point giving protection from enemy fire, which should be as near to the battalion-aid stations as possible. This station should be equipped with surgical dressings in abundance, medicines, hot food, and water for the wounded. Its functions are to sort the wounded, reapply dressings if necessary, and prevent shock.

When the collecting station is established the litter bearers of the collection section bring in the wounded from the battalion-aid stations; ambulances are used when possible.

The collecting section also establishes the ambulance station ordinarily about midway between the collecting station and the hospital station. It is merely a control point, which, when established, sends forward one or two ambulances to carry the nonwalking wounded from the collecting station to the hospital station, and then returns to the ambulance station. When loaded ambulances pass the ambulance station on their way to the rear, others from this control center are sent forward by the regulating officer to replace them. Treatment of the wounded ordinarily is not attempted between the collecting station and the hospital station.

The service section establishes and maintains the medical company mess; requisitions, cares for, and issues quartermaster supplies; and provides chauffeurs, cooks, and mechanics.

On the march, when not in the presence of an enemy, collecting stations are established along the route to provide temporary shelter for men falling out from illness or injury. These stations are evacuated by the ambulances following the troops and the casualties are carried to the camp-hospital station.

The hospital section is a relatively lightly equipped hospital, capable of free movement in the field, and establishes a hospital station to the rear of the ambulance station, thus forming a relay in the evacuation system from front to rear. In combat, this section establishes a hospital station where all sick, injured, or wounded cases are received and properly cared for. Surgical operations are performed when necessary, but the hospital section must at all times, to be fully effective, be capable of evacuating all wounded, so that the organization can advance as an active part of the field force. This would be done, when the distance is not great, by evacuating to a hospital ship or a base hospital. When a unit of a medical company which has established a hospital station fills up, another company establishes a new station and the first takes no more cases, but clears itself and then stands by to form a new hospital station. Thus during an advance the hospital sections would "leapfrog" each other.

This completes a brief outline of the mobile portion of the medical department of an expeditionary force. Under certain circumstances, however, if the distance between the hospital station and the base becomes too great, as in an advance, another medical unit must provide hospital treatment in order that the hospital section may remain mobile. This service is performed by the

evacuation hospital, which is organized with headquarters and various subdivisions similar to those of a naval hospital. As its equipment is relatively elaborate, it moves only with the aid of a large number of trucks or by rail. It is intended to give the complete or definitive treatment ordinarily given by the hospital ship or base hospital, and is used only under the condition mentioned.

The field medical supply depot on the hospital ship or with the expedition quartermaster carries sufficient medical and surgical stores for resupply for a given period. This relatively frequent resupply is necessary in order that the supply section of the medical company may remain mobile. This depot also carries more elaborate dispensary equipment for attached medical troops and hospital equipment for the medical company, which they may be able to use to advantage under certain conditions, as during the occupation of an enemy city, in a semipermanent camp, or in a defensive position from which no advance is intended.

Section 8.—LANDING FORCE

Hospital corpsmen serving on board combatant ships must also be prepared to serve ashore as members of the medical department of the ship's landing force.

Organization and equipment.

A permanently organized landing force consisting of infantry, artillery, machine guns, and other auxiliary units, is maintained on each ship and is known as the ship's battalion. It varies in size and composition according to the type of ship. For a ship of the first rate it normally consists of one company of Marines, two companies of Navy infantry, and one company of Navy artillery, a machine-gun unit, the battalion commander and staff, and special details consisting of pioneers, signalmen, cooks, messmen, and the ambulance party. This organization is flexible, so that all or any part may be landed at the discretion of the senior officer present.

The ambulance party which is commanded by the battalion surgeon, usually the junior medical officer of the ship, is ordinarily composed of two litter bearers from the line of each company, or preferably, an equal number from the ship's engineering divisions, with a chief pharmacist's mate and as many hospital corpsmen of the lower ratings as the circumstances may demand. The total number of litter bearers should not be less than 2 per cent of the number of combatants landed. During an actual engagement, in order to reduce the number of ineffectives to a minimum, messmen, orderlies, and others not actually engaged in their own legitimate duties, should be pressed into service to augment and reinforce the litter bearers. This additional personnel should recover the arms and ammunition of disabled men, assist in the transportation of the wounded, and perform such other duties as the battalion surgeon may direct. Litter bearers should invariably be drawn from line personnel.

In an actual engagement, hospital corpsmen will be so busily engaged in the dressing of wounds and in other professional work, that it will not only be impractical but will also be disastrous to even attempt to employ them in any other capacity. The assignment of hospital corpsmen as litter bearers will weaken the entire medical organization, destroy its morale and ruin its efficiency. The equipment of the ambulance party depends largely upon the nature of the battalion's duty ashore. Ordinarily the litter bearers and hospital corps-

men carry no weapons, but wear the Geneva Cross on the left arm; however against a savage or uncivilized enemy, the personnel of the ambulance company carry pistols and omit the brassard. The battalion may be assembled for landing either fully or lightly equipped.

When fully equipped each member of the ambulance party wears the uniform prescribed and carries a pack carrier (packed), haversack, rubber blanket (poncho), cartridge belt, filled canteen and wears leggings. There is no provision for carrying the overcoat on the pack. When weather conditions make it necessary to carry the overcoat it has to be worn. The haversack contains rations, knife, fork, spoon, meat can, bacon can, and condiment can; also a towel, soap, comb, toothbrush, tooth powder or paste, sewing kit, matches and tobacco and pipe, if desired. The poncho is folded to suitable size and carried in the haversack on top of the rations. The pack carrier when completely assembled should contain one-half of a shelter tent with the accompanying tent pins and pole, a blanket, one pair of trousers and one jumper, one pair of drawers and one undershirt, two pairs of socks, a white hat, and a comfortable pair of high shoes. When pack carriers are not provided, the most necessary of the above mentioned articles are carried in the blanket neatly rolled lengthwise, covered with the poncho and stopped with clothes stops, and the roll placed over the left shoulder with both ends of the roll secured together under the right arm.

When the battalion is lightly equipped the men carry filled canteens and cartridge belt and wear leggings. The blanket and poncho or the pack carrier with haversack may be prescribed if circumstances require it. The special equipment of the ambulance party is as follows:

(*a*) One litter for each two bearers.
(*b*) A Geneva-cross brassard for each man.
(*c*) A Hospital Corps pouch for each hospital corpsman. (Large for chief pharmacist's mate; small for others).
(*d*) A Geneva-cross flag on a staff.

The expeditionary medical and surgical units and the medical emergency boat boxes are available for use with the landing force.

Preparations are made by the battalion surgeon for an additional supply of instruments, dressings, and other equipment for an expedition in accordance with the length and character of the service and he will invariably make an inspection of all equipment prior to embarkation to see that medicines, instruments, dressings, and the men's clothing are ample and in proper condition. Each member of the ambulance party should wear his identification tag attached to the neck.

The mission of medical-department personnel in a landing force.

The mission of the ambulance party is to keep as many men physically fit as possible; to give prompt and efficient treatment to wounded or incapacitated personnel; to provide for rapid evacuation of casualties and to maintain and promote the morale of fighting units. Before leaving the ship, all personnel participating in the landing, should be subjected to a careful examination for the purpose of eliminating the physically unfit. If this is not done, there will be many men engaging in the landing who will not be able to keep up with their respective units, they will easily become fatigued and rapidly exhausted and therefore will be a distinct detriment to the efficiency and morale of the fighting force. Mobility is of vital importance to a landing force and the successful accomplishment of the mission assigned cannot be

gained without it. When the order is given to man the boats, personnel should leave the ship via cargo nets that have previously been secured along the hull of the vessel and not via gangways. The cargo net method of loading men into small boats is a much safer method and a much more rapid and effective procedure than the use of the gangway; this is especially true in rough weather. Medical-department personnel of the landing force should be divided into sections and accompany their respective line units; their medical equipment goes along with them. This division of personnel and equipment prevents total loss, in case an individual boat in which all personnel and supplies is being carried, is sunk. The medical equipment for a landing force is arranged in packs and is easily carried on the backs of hospital corpsmen. These packs when filled to capacity have a maximum weight of only 35 pounds and are waterproof for 10 minutes submergence. This method of carrying medical material greatly facilitates the embarkation from small boats and renders it a far less dangerous procedure than with the employment of the old and cumbersome medical and surgical chests. Reducing the weight and the bulk of medical materiél that personnel must carry is of vital importance, for hospital corpsmen must keep up with their respective units in the field, therefore anything that unduly reduces mobility detracts from efficiency.

On landing, the ship's battalion may join battalions from other ships to form a regiment, which in turn may be associated with other regiments to form a brigade. Both the regiment and brigade have a medical organization which is outlined in the Manual of the Medical Department, United States Navy. Ordinarily the ambulance party of each battalion will operate with that battalion. In an actual engagement, the important duties that medical-department personnel will be called upon to perform will fall under the following captions:

1. Relief of pain (morphine).
2. Arrest of hæmorrhage (tourniquets and compression).
3. Control of shock (artificial heat; morphine; absolute rest).
4. Immobilization of fractures (splints, often improvised. "Splint 'em where they lie").
5. Treatment of wounds:
    - (*a*) Hæmostasis.
    - (*b*) Asepsis.
    - (*c*) Suturing.
    - (*d*) Sterile dressings.
    - (*e*) Bandages and adhesive plaster.
    - (*f*) Tetanus antitoxin or combined with gas-gangrene antitoxin.
6. Evacuation (stretchers and motor transportation).

The medical-department personnel of the landing force, including company-aid men, battalion-aid station units, and collecting and ambulance sections, treat, collect, and transport wounded or incapacitated personnel from the front line to the beach. Here the responsibility of the landing force medical-department personnel ceases. The problem of transporting the wounded from the beach to the ships of the fleet rests upon the medical units afloat.

In the event that the tactical situation demands the holding of ground gained, it may be necessary for a landing force to establish a temporary camp. In the event of such a contingency it becomes the duty of medical-department personnel to plan and advise in regard to necessary sanitary measures. It is a well-established fact that failure to observe essential and fundamental princi-

ples in hygiene and sanitation brings upon the personnel engaged in field operations against an enemy greater misery and more deaths than all the bullets and machinations of the enemy. In any landing expedition the tactical situation will undoubtedly determine the location of the camp. In any camp, wherever it may be, three important sanitary problems concerning *water*, *food*, and the *disposal of wastes* must be settled.

Water from questionable sources or of doubtful purity must not under any circumstances be employed for drinking purposes. In the event that it becomes necessary to use water, the source of which is questionable, it must in all cases be subjected to chemical or physical methods of purification before being employed for drinking purposes. Boiling is the best method of rendering questionable water safe for drinking. In the event that this method is impracticable, chemical methods of purification must be used. The chemical compound that is usually employed for this purpose is calcium hypochlorite. (*See* p. 530.)

The food supply in a camp of this type is likely to be inadequate in quantity and of doubtful quality. As a precautionary measure against food infections an order should be promulgated and enforced to the effect that no food will be served unless it has been thoroughly and recently cooked.

The disposal of wastes and camp sanitation is fully discussed in the section on Field Sanitation.

Latrines should be placed to the leeward, 100 yards from the galley and mess halls and at least 75 feet from the nearest tent. In the event that the encampment is to be for a period greater than 1 week, the disposal of human excreta will be via the pit type of latrine and all latrines will be thoroughly and efficiently flyproofed. The fly menace should be combated by eliminating breeding places and destroying adult flies; by protecting all food intended for human consumption from flies; and by the disposal of human excreta in such a manner that flies cannot gain access to it.

In an encampment of this type, a sickbay will be established where all injuries and diseases will be treated as efficiently as the facilities available will permit. A record of all patients treated must be made. All cases of sufficient importance to warrant admission to the sick list will be written up on loose leaves from health records and a Form F card prepared when the case is discharged to duty or otherwise disposed of. A journal also is kept in which daily entries of all important, interesting, and pertinent data pertaining to personnel, hygiene, and sanitation are recorded. Upon return to the ship the medical entries are to be inserted in the proper health records.

Drills, inspections, and parades.

Frequently at sea or in port, the ship's battalion is formed for inspection or drill. The ambulance party assembles at a place on deck designated in the ship's organization scheme. Members of the party should report promptly in clean uniform and with the equipment specified. The party is mustered by the chief pharmacist's mate, who reports the result of the muster to the battalion surgeon, who in turn makes a report to the battalion adjutant. When the battalion surgeon is away from the ambulance party's place of assembly, the party is in charge of the chief pharmacist's mate, who should see that the men keep in formation, and refrain from loud talking or other disorder.

If the battalion is formed for inspection of the equipment, the pack carriers are unstrapped, the packs removed, unrolled and arranged as explained in the Hospital Corps Drill Book.

The ship's battalion sometimes is landed for parades or reviews. On these occasions the ambulance party follows the battalion, each litter being carried

by four bearers, the litters being horizontal and carried abreast of each other. It is landed not simply for parade, but to administer first-aid treatment in cases of sunstroke, accident, or sickness.

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Section 9.—SHORE PATROL

Whenever a fleet or vessels of the United States Navy visit a United States or foreign port it is customary to land a body of men known as the shore patrol. The purpose of this patrol is to preserve order among the men who are ashore on liberty and to enforce whatever regulations concerning the port the senior officer present may issue. A medical officer and some hospital corpsmen usually are detailed for duty with the shore patrol and become an integral part of it. The duty of the medical detachment of a shore patrol is to render emergency medical and surgical treatment to men ashore on liberty from the vessels present and to members of the shore patrol who may be injured or become ill.

The ease with which this duty may be performed depends greatly upon the nature of the port in which liberty is granted. In a well-organized community possessing an efficient police force, public hospitals, and ample facilities for handling large liberty parties, such as are found in any well-organized municipality, the problem is easy to solve. But in cities having few attractions for the men, no welfare activities, numerous liquor stores, houses of prostitution, and an inefficient police force the problem presents a different aspect. It is a port of this type which will be considered in this section.

The personnel of the medical detachment of the shore patrol should consist of one medical officer and four well-trained, reliable pharmacist's mates. Each man should carry ashore with him his field equipment, viz., a poncho, belt and canteen, extra shoes and leggings, a change of underwear and socks, an extra suit of whites or blues, hammock, mattress, cot, two blankets, mosquito net, necessary toilet articles, two towels, shoeblacking, a notebook, and pencil or fountain pen. The detachment should have a bucket for water, a washbasin, and a supply of toilet paper.

In many ports the members of the shore patrol will be quartered in a hotel, or in a comfortable military barracks or in a police station, but one never knows what is ahead of him when liberty is given in a strange port, so each pharmacist's mate detailed with the shore patrol should go ashore prepared to camp out in whatever quarters are available. He may find himself lodged in an empty warehouse or in the baggage room of a railway station.

Before leaving the ship it is necessary to assemble certain material for use in connection with the treatment of sick or injured among the liberty party. As conditions ashore are more or less unknown a fairly complete field equipment will be necessary, in which must be the following:

1. A Geneva-cross flag and staff to mark the main dressing station.
2. The medical and surgical expeditionary cases.
3. A mess table upon which to place the expeditionary cases and other appliances at the main dressing station.
4. Three folding cots.
5. Three pillows with pillow cases.

6. Three blankets.

7. Two Stokes' splint stretchers, each having a pillow and two blankets. It is advisable to place a tag bearing the name of the ship on each of these stretchers and on each blanket as they may be used for the transportation of men to the hospital ship and easily become lost unless tagged.

8. Two buckets for water.

9. Four washbasins (two for main dressing station and two for venereal prophylactic station).

10. Five hundred cc of Tincture of Iodine, or Tincture of Merthiolate.

11. An ample supply of sterile dressings and bandages. Materials to make tincture of iodine and compressed dressing material are to be found in the expeditionary cases, but it is better to use a freshly sterilized supply of dressings and to disturb the cases as little as possible as it might be impossible to renew supplies from them for some time.

12. A blank book to be used for a journal in which is to be entered an account of all the detachment's activities, especially notes of all cases treated and examinations made.

13. A package of shipping tags.

14. Material for venereal prophylaxis and report blanks which when filled out are sent to the medical officer of the applicant's ship.

The quarters for the shore patrol generally are selected by an officer of the Train, Base Force, which usually arrives in advance of the fleet. Therefore when the patrol party lands, it is marched at once with its equipment to the quarters selected. It is a good rule in Navy life never to become separated from one's baggage, so on this march from the dock to the quarters see that all the medical-department equipment is brought along and none left on the dock. Most of the material brought ashore can be packed in the two splint stretchers and carried safely with the aid of men from the patrol, who will be detailed by the senior patrol officer on request.

Having arrived at the patrol quarters, the sleeping accommodations for the pharmacist's mates are arranged for. These probably will be with the rest of the patrol, and the comfort each man gets depends upon his adaptability for service in the field. Next comes the question of food. In some ports the shore patrol will be subsisted from some vessel and the cooked food sent ashore. Usually, however, each man's ration is commuted and he is allowed not more than 75 cents for each meal. A survey of the neighborhood will reveal the best eating places. Remember that no member of a shore patrol is permitted to drink any alcoholic beverage while on duty.

The next step is to establish the main dressing station, where seriously injured men may be brought for first-aid treatment. This station should be as near the landing place as possible and should be marked by the Geneva-cross flag. Having secured a suitable location, set up the three cots and the mess table, upon which place the expeditionary cases and two of the washbasins, together with other dressing material. This table will be found very useful as a dressing stand. Secure a supply of fresh water and make up whatever antiseptic hand solution the medical officer uses, covering it with a clean towel. The splint stretchers should be prepared for use and placed out of the way. One pharmacist's mate is detailed to care for the main dressing station.

The venereal prophylactic station likewise should be established near the landing place and if possible adjacent to the main dressing station. Experience has shown that these two stations should not be combined, because if there is opportunity for much exposure to venereal disease in the port it is

likely that a large crowd of noisy men will visit the prophylactic station and if the dressing station be in the same place its proper functioning will be interfered with. This station must be in charge of one pharmacist's mate, who will prepare and supervise the treatment and fill out the treatment report blanks. He should be assisted by at least two members of the shore patrol, whose duty is to preserve order. The prevention of venereal disease is most important and must be faithfully and conscientiously carried out. It is not agreeable duty, as the patients often are under the influence of liquor, foul-mouthed, and disorderly, but if venereal disease is prevented by the treatment it is worth all the effort expended.

A dressing station equipped with a Hospital Corps pouch and a supply of sterile dressings, iodine, and bandages, and in charge of one pharmacist's mate, should be established at the landing place, as it is to be expected that many men will present themselves with minor wounds which require sterilizing and dressing before embarking for their ships. All cases of serious injury, such as fractures, severe hæmorrhage, large lacerated wounds, etc., appearing at this station should be sent to the main dressing station for treatment because at the landing there will be more or less confusion caused by embarking men, some of whom may be intoxicated.

At the landing place a space should be reserved for the reception of severely intoxicated men. This space should be so located as to safeguard the men placed in it. Many of these men will be unconscious or semiconscious, others will be noisy or talkative, while others will be fighting drunk. If these men be permitted to wander about at will there is danger of their falling off the dock into the water or onto the landing float. The space selected for the retention of drunken men should be in charge of a competent chief petty officer of the shore patrol. He should have sufficient assistants to preserve order.

The fourth pharmacist's mate should act as a relief for meals and as assistant to the medical officer. Experience has shown that none of the stations mentioned should be left unmanned while the liberty party is ashore. One never knows when a serious accident will happen. A man may be run over by a trolley car or shot or stabbed at any time. Liberty in a port such as is being discussed generally begins at noon and expires at 8 p. m., but it will probably be midnight before the dock is cleared of the last stragglers; and until all the liberty party has embarked the medical detachment must keep their dressing stations open because the patrol in their final search of the streets for the night may find some men injured or unconscious.

As soon as possible after the landing the medical officer of the shore patrol should make a sanitary survey of the port. This survey should include an investigation of the food and water supply of the port, the diseases prevalent, and the neighborhoods harboring contagious diseases or houses of prostitution. With the information so gained, and through the cooperation of the senior patrol officer he should prevent, as much as possible, the exposure of the liberty party to disease by suitable recommendation for the restriction of infected localities.

There are several special points relating to the activities of the medical department which are well to bear in mind. Frequently men are brought down to the landing place profoundly intoxicated and often unconscious. Each of them should be examined carefully by the medical officer, as the unconsciousness may be due to a head injury which necessitates immediate transportation to the hospital ship. An attempt should be made to identify every unconscious man. Examination often will show that he has no identification tag and his clothing may bear several names; therefore it becomes necessary

to learn his name and the name of his ship from his shipmates who may be around. Write this information on a shipping tag and tie it securely to his clothing, then have him placed in the space reserved for intoxicated men. This will facilitate his return to his ship. Men will be brought to the medical officer for examination to determine whether they are under the influence of liquor. If the man is found under the influence of liquor, careful notes should be made in a notebook kept for this purpose of all the details of the case—the man's name, his rating, his ship, his peculiarities, or marks by which he may be identified, and the signs or symptoms upon which the decision that he is intoxicated is made. Then get some officer or chief petty officer from his ship to identify him and record that officer's name for future reference. All this is necessary, because men often give wrong names and have no identification tag or proper marks upon their clothing, and the medical officer in all probability will be called as a witness by a court-martial in the case weeks after, and unless he has kept a very clear record of each case and has the identity of each man pronounced under the influence of liquor clearly in mind he will not be able to give clear testimony in court.

Men seriously injured may be expected at the main dressing station at any time, and provisions for their care always must be in readiness. Great care must be taken to identify each badly injured man and to place upon him a tag bearing his name, rating, and the name of his ship. All severely injured men after having been given the necessary first-aid treatment should be sent immediately to the hospital ship, where there are medical officers always on duty. If an injured man should be sent to his own ship, it is possible that the medical officers of that vessel might be ashore and the professional attention required would be lacking. Severely injured men are best transported in the splint stretcher, and may be sent to the hospital ship in either a patrol boat or a liberty boat, which may be diverted from its regular duty by order of the senior patrol officer. When an injured man is sent to the hospital ship a member of the medical detachment should accompany him to care for him enroute and to insure the prompt return of the stretcher to the dressing station.

In every case involving an injury ashore of sufficient importance to require treatment and the return of the individual to his ship, or of sufficient severity to demand direct transfer to the hospital ship or hospital ashore, an immediate report will be submitted to the senior medical officer of the ship to which the man is attached, giving answers to the following questions:

1. Was the man on authorized liberty?
2. Was the man intoxicated?
3. Was the injury due to his own misconduct?
4. Concise and pertinent facts concerning the circumstances attending the injury.

The information given under No. 4 should be so explicit that anyone with no previous knowledge of the case may read it and visualize the accident.

This report must invariably be sent to the senior medical officer of the ship to which the individual is attached whether or not the man is returned there. In the event that the injured patient is transferred direct to the hospital ship or a hospital ashore a duplicate of the report should be submitted to the activity concerned. In addition, a file copy for future reference should be retained.

This procedure is of the utmost importance but unfortunately is often neglected. The importance of this report is undoubtedly realized and appreciated by everyone in the medical department of the U. S. Navy. Injured personnel are constantly being sent to the hospital ship with no information as

to the circumstances attending the injury, or if information is submitted it is often insufficient, inaccurate, misleading, and therefore of no value. Upon receipt of such a case the senior medical officer of the hospital ship immediately sends a radio to the medical officer of the ship to which the man is officially attached requesting information at once; however this unfortunate medical officer has no more and probably less information than the hospital-ship authorities. So in the end a medical officer must go ashore and spend the major part of a day obtaining information that the patrol officer could have easily secured at the time the accident occurred, thus saving much inconvenience, time, labor, and expense.

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CHAPTER VII

DIETS AND MESSING FOR THE SICK

Feeding the sick has become so important a factor in their treatment and cure that it may well be termed **Diet Therapy** and placed among the other remedial agents employed in therapeutics. While not actually a remedy in itself, diet therapy supplements and makes other treatment more effective. Where formerly the feeding of the sick was based largely on experience and observation and the patient's whims and fancies as well as his physical disability, today, because of the marked increase in the scientific knowledge of the composition of foodstuffs, of their metabolism in the body, and of their relation to normal and pathological conditions in the body, it is a science. Due to variable factors such as age, temperament, idiosyncrasy, etc., influencing metabolism, it cannot be classed as an exact science and consequently diets for the sick require more or less individual prescription. In common with all sciences, dietetics requires a knowledge of the other sciences with which it is allied.

Nutrition is the process of providing the body with the necessary material for maintenance, growth, and renewal of all the body tissues.

Dietetics is the science which treats of food and its effect on the body in health and disease.

Foods are those substances obtained from the animal, vegetable, and mineral kingdoms which, when taken into the body, yield heat and energy, build and renew tissues, and regulate the body processes and internal conditions. They usually are classified as *proteins*, *carbohydrates*, and *fats*, and equally essential for life are *water*, *inorganic mineral salts*, and *vitamins*. Foods contain other substances which, while not absolutely necessary, are useful in nutrition through increasing or improving the palatability of food and stimulating the flow of digestive juices. These substances are known as accessory articles of diet and consist of: *Flavors*, various substances that give odor and taste to foods; *condiments*, as pepper, salt, mustard, etc., and *stimulants*, as alcohol, tea, coffee, cocoa, etc.

Proteins, the only class of foods containing nitrogen, sulfur, and phosphorus as well as carbon, hydrogen, and oxygen, are found in both the animal and vegetable kingdoms. All proteins are built up of amino acids, the proportions of which differ widely in proteins obtained from different sources. Some of these amino acids are absolutely essential for the maintenance of life while others are necessary for the growth and development of the body. The difference in proportions of amino acids determines the biological (or nutritive) value of proteins and according to their amino-acid content proteins are known as "complete," as those found in lean meat, milk, and eggs, "partially complete," of which type those in cereals and legumes are examples, and "incomplete," as gelatin.

Proteins are essential in food to promote growth and renew tissue. They also yield energy but are an expensive source of it. Deficiency of protein in the diet will stunt growth, promote a secondary anæmia or induce nutritional œdema. The amount of protein necessary in the daily diet is a disputed point. Experiments have shown a minimum of 0.6 Gm. per kilogram of body

weight to be necessary. An optimal amount is from 1.0 to 1.5 Gm. per kilogram of body weight, or 70 to 100 Gm. a day for a man weighing 70 kilograms. Part of this protein should be of good biological value, as protein from animal sources.

Carbohydrates, containing carbon, hydrogen, and oxygen, are found largely in the vegetable kingdom, are easily procured and inexpensive, and usually represent from 50 to 75 per cent of the normal diet. Examples are sugars, syrups, grains, vegetables, and fruits. They are also found in milk, and are the most valuable source of energy. They are protein sparers in the body if for any reason proteins must be curtailed. They may be stored in the liver as glycogen to be used by the body when needed, and when taken in excess are stored as adipose tissue. When taken too sparingly, weight is lost and acidosis may result. Carbohydrates are essential for the metabolism of fats. In the form of glucose, carbohydrates are the most valuable emergency fuel for the body.

Fats, like carbohydrates, contain carbon, hydrogen, and oxygen, but in different proportions and are found in both animals and vegetables. Examples are butter, cream, cheese, fat meats, egg yolks, nuts, and vegetable oils. They are the most concentrated source of energy, are protein sparers, and are essential for all cells. Fat acts as a padding both for organs and subcutaneous tissue and is stored up as adipose tissue to form a reserve supply in time of need. The fat requirement varies with the individual, and also depends on his protein and carbohydrate intake. In the normal diet fats usually make up from 35 to 50 per cent of its calories. An excess of fat in the diet is apt to promote indigestion. It is bound to produce obesity, the forerunner amongst the middle-aged of arteriosclerosis, hypertension, diseased gall bladder and diabetes.

Water, composed of hydrogen and oxygen, makes up two thirds of the body weight and is found in every cell in the body. It is the most important single item in the diet, and is found in all beverages and in all foods not artificially dehydrated. Six to eight glasses of water a day is a normal intake. Taken in excess water may overtax a diseased heart and kidneys, while an insufficient intake causes constipation, loss of weight, disturbs the maintenance of normal body temperature, and causes dehydration inducive to ketosis.

The **inorganic mineral salts** found in the body are calcium, phosphorus, magnesium, potassium, iron, sodium, chlorine, iodine, copper, and others in small amounts. The more important ones will be discussed briefly.

Calcium. Good sources of calcium are milk, cheese, egg yolk, dried beans, almonds, peanuts, walnuts, turnips, oranges, and dried prunes. Most of the calcium in the body is found in the bones and teeth, but is by no means limited to this use. It is essential for the coagulation of blood, for normal heart action, and for contractility of the muscles. Deficiency of calcium in the diet, and this is the most common deficiency in the American diet, causes faulty structural development, rickets, dental caries, heart atony, tetany, and excessive bleeding. The amount of calcium needed in the daily diet is 0.68 Gm. for an adult. This is increased to 1.0 Gm. a day for a child. One pint of milk a day will keep an adult in positive calcium balance while 1 quart of milk is necessary for a child.

Phosphorus is found in cheese, eggs, whole grain cereals, meat, dried beans and dried prunes in good amounts. Two-thirds of the phosphorus in the body is found in the bones and teeth. It is also found in every cell in the body and thus is essential for growth. If the phosphorus intake is not sufficient, the results are poorly developed bones and teeth, retarded growth, and rickets. An adult needs 1.32 to 1.5 Gm. of phosphorus a day, and the growing child needs more.

Iron. Good sources of iron are liver, kidney, heart, beef, egg yolk, oatmeal, dandelions, almonds, apricots, peaches, green vegetables, and dried fruits. It is essential for the formation of hæmoglobin and lack of it in the diet causes anæmia. Fifteen milligrams of iron daily is necessary in the diet of an adult. This amount is increased in the diet of a child and in nutritional anæmias.

Copper has been found in recent years to be absolutely essential for the utilization of iron in the body. Although the daily requirement is very small, 0.0002 Gm., anæmia will develop without it. Copper is found in liver, bran, seafoods, nuts, leafy foods, and legumes.

Iodine is found in fish and vegetables of nongoiterous regions. It is essential for the normal functioning of the thyroid gland and lack of a sufficient amount will cause goiter. The amount needed daily is not known but different goiter belts prescribe from 15 micrograms for an adult to 150 micrograms for a child. As the iodine content of the foods and drinking water in these regions is so variable, or lacking entirely, iodine is introduced in the drinking water or table salt and is sometimes given in weekly doses in the schools. A microgram is one millionth of a gram.

Vitamins are substances which are absolutely necessary for the maintenance of health and were once called "food factors of unknown natures." Later they were thought to be amines necessary for life and were given the name of "vitamines." Many years of scientific investigation has proved their existence and that they are essential to health beyond the possibility of doubt. They now are known as "vitamins" (the letter "e" having been dropped from the spelling of the word) which is considered to signify only that they are essential to life. It is an unsatisfactory name but a better one has not yet been chosen. Their chemical composition is gradually becoming known, pure preparations of most of them have been made from natural sources, some have been prepared artificially in the laboratory, and much has been learned about the part they play in life and health. The existence of 6 vitamins has been established, more are recognized, the existence of others is suspected, and some now considered to be single vitamins may be found to consist of 2 or more. An antihæmorrhagic dietary factor, to be known as vitamin K, has been discovered and appears to be concerned with the regulating of the time required for blood to clot. Vitamins are designated by letters of the alphabet in the order of their discovery, except vitamin B which was discovered shortly before vitamin A.

Vitamin A is called "fat soluble" because it is soluble in fats. Very little of it is destroyed by ordinary cooking as it is only slightly soluble in water and is very little affected by heat. It is destroyed by drying. Taken in excess it can be stored in the liver. Sources of vitamin A are fish-liver oils, liver, fish roe, egg yolk, milk, butter, cheese, escarole, lettuce, carrots, sweet potatoes, apricots, and peaches.

Vitamin A stimulates growth and development, and is necessary for well-being at all ages. It has a definite part in the maintenance of the normal protective function of the mucous membranes lining the nasal passages, the mouth, the throat, the intestinal tract and various other body cavities. A long-continued deficiency results in arrested growth, defective tooth and bone formation, nutritional night blindness, and loss of reproductive power. Deficiency also causes *xerophthalmia*, a condition of the eyes and lacrimal glands which may result in total blindness.

Vitamin A itself occurs only in animal and sea foods but plant foods having a deep yellow or green color contain certain pigments which are changed into vitamin A in the body, and are known as ***provitamin A***.

The daily requirement of vitamin A for an adult is 5,000 to 6,000 International units. One quart of milk will furnish about 1,000 International units of vitamin A and 1 Gm. of calcium.

Vitamin B is now known as "vitamin B complex" for the reason that scientific investigation has shown it to be a complex dietary factor instead of a simple one as was at first believed. The existence of 5, and possibly 6, factors having distinct and separate biological properties has been determined, which, for convenience, have been designated as vitamins B_1, B_2, B_3, B_4, B_5, and B_6. In the United States vitamin B_2 is also known as vitamin G.

Vitamin B₁, or *thiamin*, and sometimes called *aneurin*, is known as the *antineuritic vitamin*, is soluble in water, and destroyed by heat. Some of it is lost in improper cooking, by refining, and by the addition of alkalis. Being water soluble much of the vitamin B_1 contained in fruits and vegetables may be in the water in which they are cooked, and it is therefore advisable to use as little water as possible in cooking them and to serve the cooking liquor with the foods. The liquor with canned fruits and vegetables should also be used. It is found in small amounts in many foods, good sources being whole-grain cereals and breads, yeast, dried beans, broccoli, and other green vegetables, chicken, brains, liver, kidney, and lean pork. It is also manufactured commercially.

Vitamin B_1 is necessary for the normal functioning of the nervous system and for normal muscle tone of the alimentary tract, and it is believed general health and well being could be much improved if more of it was contained in the daily diet. It is also necessary for the normal oxidation of sugars in the body. A deficiency stops growth and causes loss of appetite, a sluggish digestive system, and nervous irritability. Absolute lack of vitamin B_1 produces the disorder of the nervous system known as *beriberi*. Vitamin B_1 does not stimulate normal appetite as is sometimes claimed.

The daily requirement for this vitamin is believed to be about 400 to 500 International units.

Vitamin C, or *ascorbic acid*, and also known as *cevitamic acid*, is the *antiscorbutic vitamin*, is water soluble, and is destroyed in cooking (when air is present) as well as in the presence of alkalis. It can be stored in the body in a limited degree and is found largely in the vegetable kingdom. It is present also in the suprarenal glands. Excellent sources are green vegetables, peppers, turnips, horseradish, most fruits, sprouted seeds, liver, and brain. Citrus fruits and tomatoes are especially rich in this vitamin. Raw fruits and vegetables are preferable for supplying this vitamin although canned fruits and vegetables are good sources as, in most cases, air is excluded during the cooking process.

Vitamin C is essential for growth and good health. It is particularly important for normal capillary blood vessels, good teeth, and healthy gums. Bleeding gums, loose teeth, sore joints, loss of appetite with loss of weight and fatigue, are symptoms of a lack of vitamin C and of the disease known as scurvy.

An adequate allowance of vitamin C for the adult is 1,200 to 1,500 International units which can be supplied by one large orange or one-half a grapefruit.

Vitamin D, the *antirachitic vitamin*, is fat soluble and is not destroyed by ordinary cooking. It is not widely distributed in foods being found naturally in only a few in important quantities. Foods containing certain substances known as provitamin D when exposed to ultra-violet rays become sources of vitamin D into which the provitamin D is changed. Ergosterol, a complex

substance resembling fat or oil but not saponifiable, and widely distributed in plant and animal tissues, of which the skin is one, is changed into vitamin D on exposure to ultra-violet rays.

This vitamin is necessary for the utilization of calcium and phosphorus in the body and is therefore essential for the formation of bones and teeth. A lack of it retards growth, especially of bones and teeth, and an excessive deficiency results in rickets, a disease that until recently afflicted in some degree nearly 80 per cent of the children in large cities in America and western Europe.

The daily requirement of vitamin D for adults is not known but 400 to 600 International units provide for good growth and maximum calcification in infants. Overdoses of this vitamin are toxic. Egg yolk, fish-liver oils, salmon, sardines, and dairy products are good sources of this vitamin, as are foods enriched by irradiation. The concentrates, as fish-liver oils, are advised for use in the winter months, especially for children.

Vitamin E, the *antisterility vitamin*, is fat soluble and heat stable, and is essential for reproduction. It is found in small quantities in many foods, the germ of the wheat grain being an especially rich source. It is not deficient in the human diet as it is present in green lettuce, vegetable oils, and a number of other vegetables in considerable quantities.

Vitamin G, or *riboflavin*, is also known as vitamin B_2. It is a yellow pigment widely distributed in both animal and plant foods, is water soluble, and is not easily destroyed in cooking except in the presence of alkalis. The best sources of this vitamin are lean meat and glandular organs, eggs, milk, and green vegetables, and it is also found in the germ portion of wheat, in peanuts, soybeans, and rice polishings.

The use of vitamin G in the body is not yet clear but it is believed to play a part in the chemical processes of all living cells and it has been stated that it increases nutritional well-being. Experiments on animals have shown that a deficiency results in retarded growth, loss of hair, and nutritional cataract. No figures are yet available for the amount needed daily but protection is supposed to be afforded by 1 pint of milk, 1 serving of turnip greens, 1 serving of grapefruit, 5 slices of whole-wheat bread, or 1 egg.

The **P-P (pellagra-preventing) factor**, or *nicotinic acid*, was identified in 1937. An insufficient amount of this factor in the diet appears to be the chief cause of pellagra, a disease common in the southern part of the United States and to alcoholics. It is found in liver, lean meat, salmon, egg yolk, buttermilk, collards, green peas, turnip and other greens, and tomato juice.

Deficiency of this factor first is followed by loss of appetite, loss of weight, and general weakness. If the deficiency is prolonged sore mouth, digestive and nervous disturbances, and eruptions on the skin of the hands, arms, feet, and legs result. This factor is still in process of study and no figures are yet available as to the daily requirement. It is known that 1 to 2 milligrams daily will cure pellagra.

ENERGY VALUE OF FOOD AND PLANNING THE DIET

An extremely important function of food is to supply energy. The energy value of food is variously referred to as its fuel or caloric value. In food chemistry the unit used to measure the caloric value of food substances is the large calorie which is the amount of heat necessary to raise the temperature of 1 kilogram of distilled water from zero to 1° C.

The energy or heat value of foods is determined by the use of calorimeters, experiments with which have shown that foods furnish the same amount of

energy when used in the body as when burned in calorimeters, providing the end products in each case are the same. Experiments also have shown the fuel values for the different classes of foods to be approximately as follows:

1 Gm. of protein yields 4 calories.
1 Gm. of fat yields 9 calories.
1 Gm. of carbohydrate yields 4 calories.

The food requirements of individuals are affected by several factors, muscular activity, age, size, shape and weight, body composition, influence of ductless glands, pathological conditions, pregnancy and lactation, effect of food, climate, etc. It should be remembered that a certain amount of food is required to maintain the body at all times.

The first step in determining the energy needs of the individual is to find the ideal weight according to the age and height. The weight-height-age tables put out by insurance companies and other authorities may be used for this purpose. From the standpoint of good health, it is considered undesirable to be underweight before 30 or overweight after that age. This makes the weight at 30 years of age in the tables ideal for most adults. Tables of average heights and weights are given immediately hereafter.

TABLE OF AVERAGE HEIGHTS AND WEIGHTS—MEN

[From Nutrition and Diet Therapy—Proudfit]

Age	5 feet, 0 inches	5 feet, 1 inch	5 feet, 2 inches	5 feet, 3 inches	5 feet, 4 inches	5 feet, 5 inches	5 feet, 6 inches	5 feet, 7 inches	5 feet, 8 inches	5 feet, 9 inches	5 feet, 10 inches	5 feet, 11 inches	6 feet, 0 inches	6 feet, 1 inch	6 feet, 2 inches	6 feet, 3 inches	6 feet, 4 inches	6 feet, 5 inches
15	107	109	112	115	118	122	126	130	134	138	142	147	152	157	162	167	172	177
20	117	119	122	125	128	132	136	140	144	148	152	156	161	166	171	176	181	186
25	122	124	126	129	133	137	141	145	149	153	157	162	167	173	179	184	189	194
30	126	128	130	133	136	140	144	148	152	156	161	166	172	178	184	190	196	201
35	128	130	132	135	138	142	146	150	155	160	165	170	176	182	189	195	201	207
40	131	133	135	138	141	145	149	153	158	163	168	174	180	186	193	200	206	212
45	133	135	137	140	143	147	151	155	160	165	170	176	182	188	195	202	209	215
50	134	136	138	141	144	148	152	156	161	166	171	177	183	190	197	204	211	217
55	135	137	139	142	145	149	153	158	163	168	173	178	184	191	198	205	212	219

TABLE OF AVERAGE HEIGHTS AND WEIGHTS—WOMEN

[From Nutrition and Diet Therapy.—Proudfit]

Age	4 feet, 8 inches	4 feet, 9 inches	4 feet, 10 inches	4 feet, 11 inches	5 feet, 0 inch	5 feet, 1 inch	5 feet, 2 inches	5 feet, 3 inches	5 feet, 4 inches	5 feet, 5 inches	5 feet, 6 inches	5 feet, 7 inches	5 feet, 8 inches	5 feet, 9 inches	5 feet, 10 inches	5 feet, 11 inches	6 feet, 0 inch
15	101	103	105	106	107	109	112	115	118	122	126	130	134	138	142	147	152
20	106	108	110	112	114	116	119	122	125	128	132	136	140	143	147	151	156
25	109	111	113	115	117	119	121	124	128	131	135	139	143	147	151	154	158
30	112	114	116	118	120	122	124	127	131	134	138	142	146	150	154	157	161
35	115	117	119	121	123	125	127	130	134	138	142	146	150	154	157	160	162
40	119	121	123	125	127	129	132	135	138	142	146	150	154	158	161	164	167
45	122	124	126	128	130	132	135	138	141	143	149	153	157	161	164	168	171
50	125	127	129	131	133	135	138	141	144	148	152	156	161	165	169	172	176
55	125	127	129	131	133	135	138	141	144	148	153	158	163	167	171	174	177

After the ideal weight for age and height has been determined, the influence which activity has on food requirements must be considered and calorimeter

studies of individuals in different states of activity have shown the requirements to be as follows:

Activity	Calories per kilo	Total calories
Basal	20	1, 200–2, 000
Bed rest	25	1, 300–2, 200
Light work	30	1, 600–2, 500
Moderate work	35	1, 800–3, 000
Heavy work	50	2, 200–4, 000

After determining the total amount of food required it is necessary to determine how much protein, fat, and carbohydrate should be used to supply the desired number of calories. There is some difference of opinion as to this, although it is known, to a fair degree of accuracy, the amount of each which can be utilized to the best advantage. The total amount of food required depends largely upon the amount of exercise taken. The protein metabolism, however, does not depend so much upon the amount of exercise as it does upon the amount of food taken. It is known that carbohydrates and fats protect the body protein, and if a diet is used which is low in protein, nitrogen equilibrium may be obtained by adding fats and carbohydrates to the diet, providing, of course, the protein intake does not fall below the minimum requirement. Ordinarily the protein intake, to supply the average body requirements, need not exceed 120 Gm. nor be under 60 Gm. daily, and the optimum probably lies between these figures, varying with the individual conditions.

As regards the amount of fat and carbohydrates in the average diet, there is also some difference of opinion, although the figures do not vary as much as for the protein.

It is an easy matter to determine the quantities of carbohydrates, proteins, and fats necessary to produce any number of calories in a diet by using the percentages of distribution of each class of food and the caloric value of each. If, in a diet having a distribution of 50 per cent carbohydrates, 15 per cent proteins, and 35 per cent fats, it is desired to provide a total of 2,400 calories, it is first found that—

Carbohydrates should furnish 50 per cent of 2,400 calories or 1,200 calories;
Proteins should furnish 15 per cent of 2,400 calories or 360 calories; and
Fats should furnish 35 per cent of 2,400 calories or 840 calories.

Having found the number of calories to be furnished by each class of food, by using the caloric values of each class as given before in this section, it is next found that there will be required to furnish a total of 2,400 calories:

1,200÷4, or 300 Gm. of carbohydrates;
360÷4, or 90 Gm. of proteins; and
840÷9, or 93.3 Gm. of fats.

In planning a diet in an individual case it should be remembered that undernutrition lessens the natural power of resistance to diseases, while overeating puts unnecessary strain on the organs of digestion and elimination, favors obesity, and increases the amount of waste products. Probably the best way to work out a diet is first to determine the number of calories required, of which amount, from 10 to 15 per cent should be furnished by protein. The nature of the protein should be considered, and those containing the necessary amounts of amino-acids should be included. The

proteins found in milk and meat are, as a rule, more valuable than those in vegetables. The remainder of the calories is made up from fats and carbohydrates. These are interchangeable within certain limits. Ordinarily the amount of fat taken does not exceed 60 to 100 Gm. per day and the balance is made up of carbohydrates.

The diet also should contain the various salts needed in metabolism and in a general mixed diet they are almost always present, although in restricted diets the quantity may be too low. In ordinary diets the requirements are easily met if milk products, salads, and other green vegetables are included and the importance of so including them must be emphasized.

Foods ordinarily should furnish more bases than acids, and meats, cereals, and other acid-forming foods should be offset by those containing alkalies, as potatoes, bananas, vegetables, and fruits.

The inclusion of vitamins is important and necessary.

There always should be an antiscorbutic in the diet such as some fresh fruit or vegetable. The food also should contain sufficient bulk.

Flavors and condiments have no nutritive value, but are used to increase the appetite by rendering food more palatable and adding savor to the diet. Spices are represented by such substances as ginger, cinnamon, nutmeg, and cloves; flavoring extracts by vanilla, lemon, and strawberry; and condiments by mustard, horseradish, pepper, salt, and vinegar.

Beverages, as tea and coffee, may be regarded as stimulants due to the effect of caffeine; cocoa contains carbohydrates, fats, and proteins. The various meat extracts contain little in the way of food value, but have a stimulating effect on the digestive secretions.

An adequate diet for a normal individual should consist of foods producing sufficient calories to maintain ideal body weight, of which carbohydrates furnish 50 to 75 per cent, proteins 10 to 15 per cent, and fats 35 to 50 per cent of the total caloric requirements, and the protein requirement may be considered for estimating purposes as 0.66 to 1.5 Gm. per kilogram of standard weight. In such an adequate diet there should be the amounts of inorganic mineral salts and vitamins shown in the following table:

Minerals	Vitamins
Calcium (0.5 to 0.800 Gm)	A—5,000 to 6,000 International units.
Phosphorous (1.0 to 1.500 Gm)	B—400 to 500 International units.
Iron (0.015 Gm)	C—1,200 to 1,500 International units.
	D—Amount for adults not definitely known but it is essential that foods containing it be provided in the diet.
	Foods known to contain the other vitamins should be used generously in the diet.

The composition of an adequate diet is shown in the following table:

Analysis of Adequate Diet

(From Nutrition and Diet Therapy—Proudfit)

Food	Wt. in Gms.	Portions in household measures	Cbos. in Gms.	Prot. in Gms.	Fat in Gms.	Cal. in Gms.	Phos. in Gms.	Iron in Gms.	Vitamins A	Vitamins B	Vitamins C	Vitamins G
Milk, whole	480	1 pt. (adult)	24.0	16.0	19.0	0.576	0.446	0.0012	1,200.0	96.0	9.6	288.0
	960	1 qt. (child)	48.0	32.0	38.0	1.152	0.892	0.0024	2,400.0	192.0	19.2	576.0
Bread, whole-wheat	150	5 thick slices	77.5	12.5	2.5	0.075	0.375	0.0030		220.0		
Egg	50	1 whole		6.7	5.2	0.033	0.090	0.0015	550.0	25.0		55.0
Butter	45	3 tbsps.		0.45	36.0	0.0072	0.0076	0.00009	1,287.0			
Meat, fish, or poultry	120	1 large or 2 small servings		30.0	22.0	0.016	0.320	0.0044	80.0	60.0		163.2
Cereal or equivalent	60	1 serving (30 Gms. rolled oats)	20.0	5.0	2.0	0.019	0.126	0.0011		60.0		
		1 serving (30 Gms. macaroni, etc.)	22.0	4.0		0.106	0.043	0.0004				
Fruit: 12% orange	100 to 150	1 medium	12.0	1.0		0.045	0.021	0.0005	67.0	60.0	65.0	35.0
15% apple	100	1 small	15.0	0.5	0.5	0.007	0.012	0.0004	80.0	25.0	25.0	20.0
20% banana	50	½ small	11.5	0.6	0.1	0.004	0.014	0.0003	137.5	15.0	9.0	17.5
Vegetables:												
10% string beans	100	¾ cup (if young estimate as 5%)	7.7	2.4	0.2	0.050	0.051	0.0010	1,000.0	40.0	25.0	25.0
5% tomato	100	1 medium	4.0	1.0	0.5	0.010	0.026	0.0004	1,500.0	17.5	15.0	6.5
Potato (white) 20%	100	1 small or ¾ cup riced	19.0	2.0		0.050	0.051	0.0010	40.0	40.0	15.0	25.0
Cream 20%	120	½ cup	5.5	3.0	22.0	0.112	0.096	0.0002	750.0			
Jelly, jam	15	1 heaping tbsp.	15.0									
or molasses		1 scant tbsp.										
Mayonnaise	13	1 tbsp.	0.5		11.0	?	?	?				
Sugar	45	3 tbsp.	45.0									
Pudding (cornstarch)	(?)	3 rounded tbsp	26.0	3.0	3.5	0.018	0.084	0.0002	?	?	?	?
Total calories, nutrients, and vitamins		2678 to 2987.9	304.7 to 328.7	88.15 to 104.15	124.5 to 143.5	2.1282 to 2.7042	1.7626 to 2.2086	0.01569 to 0.01689	6,691.5 to 7,891.5	758.5 to 854.5	163.6 to 173.2	633.2 to 921.2

The foods contained in the adequate diet analysed in the preceding table may be used in a menu arranged as follows:

BREAKFAST:
- Fruit—1 orange with 2 teaspoonfuls sugar:
- Cereal—1 serving, with
- Cream (medium)—¼ cup and 2 teaspoonfuls sugar if desired;
- Egg—1 whole, prepared as desired;
- Bread—1 to 2 slices with 2 teaspoonfuls butter;
- Beverage—1 glass milk for children;
- Jam, or equivalent—1 tablespoonful.

LUNCHEON OR SUPPER:
- Cereal (macaroni)—1 serving cooked with 1 ounce grated cheese;
- Fruit— } 1 serving { 1 small banana;
- Vegetable— } 1 serving { lettuce, 3 to 5 small leaves;
- Salad dressing— } 1 serving { 2 teaspoonfuls mayonnaise or salad dressing;
- Bread—2 slices, whole-grain preferred;
- Milk—1 glass;
- Butter—1 tablespoonful.
- Fruit—1 serving applesauce (1 medium cooked with 1 tablespoonful sugar);
- Cream (medium)—2 tablespoonfuls.

DINNER:
- Meat—1 serving roast beef;
- Potato—1 medium;
- Vegetables { 10%—1 serving string beans (if very young, will come under 5% group);
- Vegetables { 5%—1 tomato, raw (medium);
- Salad dressing—1 tablespoonful;
- Bread—1 slice;
- Butter—4 teaspoonfuls;
- Dessert—1 serving rice, tapioca, or cornstarch pudding.

As a knowledge of the composition, use, and digestibility of foods is essential in the planning of diets, the principal food substances are next discussed briefly.

Animal foods.

The flesh of animals, poultry, and fish is classed as meat and is one of the most important articles of food. Meat is man's chief source of protein and contains muscle tissue, connective tissue, blood vessels, nerves, and lymphatics, together with a varying amount of fat.

Cooking has the effect of rendering connective tissue soluble and allowing the digestive secretions to mingle more freely with the muscle fibers. It also improves the flavor and appearance of the meat and destroys bacteria which may be present in the meat.

Beef.—An ox from 3 to 5 years old supplies the best beef. The meat of a very lean animal will contain about 75 per cent of water and 2 per cent of fat. The muscles least exercised are the most tender and make the best roasts and steaks. Beef juice is nutritious when properly prepared and contains from 5 to 10 per cent of protein.

Veal.—Veal is more difficult to digest than beef and is obtained from calves 6 to 10 weeks old. In some persons it tends to produce digestive disturbances and is to be avoided in cases of digestive disability.

Mutton.—Mutton is obtained from the 3- to 5-year-old sheep and is considered by some writers more digestible than beef.

Lamb.—Is obtained from sheep less than a year old and is as digestible as beef or mutton but contains relatively too much fat.

Pork.—Pork is the most indigestible of all meats on account of the large percentage of fat it contains.

Ham and bacon.—Ham and bacon are both more digestible than pork. When cooked crisp, thin slices of bacon are digested easily.

Animal viscera.—Animal viscera are not quite so nutritious as most meats. Tripe, liver, kidney, and brains are used extensively. The heart is tough and indigestible. Sweetbreads, either the pancreas or the thymus gland of the calf, are digested easily. In recent years liver and kidney have been used extensively in the diet because of their vitamin and iron content. Liver and the extract therefrom are specific in the treatment of pernicious anæmia.

Poultry.—Chicken is one of the most digestible and agreeable varieties of meat. Squab is also a desirable and easily digested food. Game birds are digested easily and are richer in extractives.

Fish.—Fish is used very widely as a food and is always best used in season. Fish are in best condition just before spawning. After this process they become thin and unfit for food. Fish undergo decomposition rapidly and as a rule should be eaten in as fresh condition as possible. Shell fish (oysters, clams, and mussels) may be eaten raw or cooked. Oysters, when eaten raw and fresh, are very digestible but when cooked are less easily digested.

Eggs.—Hens' eggs are consumed in large quantities and those of the duck, turkey, guinea hen, and wild fowl also are eaten. Eggs contain mainly protein and fat in addition to water and are extremely valuable in the diet because of their vitamin and mineral content. Eggs are highly nutritious and when served with milk or broth form an important article of diet for convalescent patients.

Milk.—Milk is probably the most important of animal foods, containing all the elements necessary for the maintenance of life. It forms the exclusive diet for young growing mammals but is unsuited as an exclusive diet for adults. It contains about 4 per cent of fat, 3.3 per cent of protein, 5 per cent of carbohydrate, 0.7 per cent of mineral matter, and 87 per cent of water. Milk is a valuable source of vitamins A, D, and G. Heat is employed in keeping milk, usually by two methods—either sterilization or pasteurization. *Sterilization* is accomplished by boiling for 10 minutes or longer. There are certain objections to sterilized milk as boiling kills the ferments and places milk in the class of so-called "dead foods." It may be used to advantage, however, in very hot weather when ice is not available. *Pasteurization* means heating milk to a degree sufficient to kill harmful bacteria but with the least possible effect upon its value as a food. *See* page 382 for pasteurizing methods. While pasteurization kills most of the bacteria, particularly the pathogenic bacteria, it does not render the milk sterile; however, it does not materially change the composition of the milk as does sterilization. Pasteurized milk must be kept cool to prevent deterioration.

Vegetable foods.

Vegetable foods differ from animal foods in that they contain more starch and sugar and a relatively small amount of protein.

Cereals.—These are the most important of the vegetable foods and to this class belong wheat, corn, rye, oats, barley, rice, and buckwheat. The cereals are supplied chiefly in the form of flour or meal.

Legumes.—Peas and beans are the most important legumes and contain a liberal proportion of protein. Lentils are used comparatively little in the United States, but are used extensively in other countries. Peanuts belong to this class and differ from other legumes in that they contain a large amount of fat. The principal legumes, peas and beans, should be well cooked so that the cellulose enclosing the vegetable cells is broken down.

Roots and tubers.—This includes potatoes, sweetpotatoes, yams, artichokes, beets, carrots, parsnips, turnips, and radishes. They contain both starch and sugar but are relatively lower in nutritive value than either legumes or cereals.

Green vegetables.—Green vegetables are valuable not only on account of their nutriment but for variety and relish and for their content of salts and vitamins. They also give bulk to the food which is important on account of its mechanical action in maintaining a healthy alimentary tract. The principal articles of food in this class are cabbage, cauliflower, spinach, lettuce, sorrel, tomatoes, eggplant, cucumbers, asparagus, rhubarb, pumpkin, squash, onions, and garlic.

Fruits and nuts.—Fruits are used extensively as flavoring agents. Their chief nutrient constituent is sugar, the principal sugar being levulose and sometimes cane sugar. The mineral elements of fruit contain potash with tartaric, stearic, and malic acids. The antiscorbutic properties of fruits are due to their salts and vitamins. Fruits also act as diuretics and laxatives. The most easily digested fruits are oranges, lemons, grapes, and peaches. Apples, pears, and bananas are slightly less digestible.

Nuts contain a large quantity of fat and somewhat more protein than fruits. They are taken mainly as a dessert and as a rule do not constitute a large source of nutriment. They are not digested easily as a rule, owing to the large amount of cellulose and high proportion of fat.

DIET THERAPY OR DIET IN DISEASE

In feeding the sick it is advisable to carry out the patient's wishes whenever practicable, and to a certain extent make allowance for likes and dislikes and certain idiosyncrasies. A tactful, observing, and sympathetic nurse who acquaints himself or herself with these facts will be of the greatest help to the medical officer in carrying on his dietary régime. The nurse should have a knowledge of practical dietetics and of the amount of food required by different types of patients.

Food should be given at regular intervals. This is particularly important in semiconscious or comatose patients, and in the conscious patient regularity in meals is also of distinct advantage.

The appetite of the convalescent patient requires catering to, as patients in this condition are apt to be more fastidious than when they are well.

The sick room should be neat, and no dishes, utensils, or food allowed to stand about the room either before or after using. Food and drink should be served from scrupulously clean utensils. These utensils should be as attractive as possible, and the food must be dainty and appetizing in appearance. If the patient approaches his food with the flow of his digestive secretions stimulated by the psychic reaction to the odors and appearance of the food, he is in a position to get the greatest amount of good from his meal. An attractive dish, garnished with sprigs of green, accompanied by clean linen and bright silverware, will go a long way toward accomplishing this result.

Food that is stale or has acquired an unpleasant odor or taste from standing in a refrigerator should never be given. A strong egg in an eggnog or an odorous piece of meat may be the means of turning the patient away from much needed nourishment.

The patient should be made to feel that the utmost cleanliness and care have been observed, and the face and hands of the patient should be cleansed before food is given, and the lips and teeth cleansed after the meal is completed. If the mouth is dry, it should be moistened from time to time with a mixture of water, glycerin, and lemon juice.

When special diets are ordered, the contents of the tray should be checked with the written orders. An error in serving a special diet may cause discomfort, serious illness, or even death.

If an order is given to record the intake of food or drink for a patient, it should be kept accurately and be available for the medical officer at all times; it is essential for his treatment of the patient.

To recapitulate, the tray should be served with the proper diet and arranged in an attractive manner. Hot foods should be served on hot dishes and cold food on chilled dishes. A restful atmosphere is conducive to a good appetite and good digestion.

Diets used in the treatment of disease are often spoken of by names that show a special composition and often indicate the purpose for which the diet is intended. Some of these names are: High-caloric, low-caloric, high-roughage, low-residue, salt-free, salt-poor, high-fat, low-fat, fat-free, fat-poor, high-calcium, high-carbohydrate, low-protein, diabetic, ketogenic, obesity, etc.

A brief description of the diets suitable for certain diseases is given next.

Allergies.—Food allergy diets are high-caloric diets made up from a more or less restricted dietary list. They may be made up from "elimination" diets or from the patient's skin sensitization list. In the latter case, all foods to which he reacts positively are excluded from his diet.

Anæmia.—The diet in anæmia should consist of easily digested foods rich in iron and copper, such as eggs, liver, kidney, beef and other meats, green vegetables, whole grain cereals, fresh and dried fruits, and dried legumes.

Cardiac diseases.—In acute heart failure with œdema, the patient usually is placed on a restricted diet consisting of 800 to 900 cc of milk in 24 hours until the œdema tends to disappear. The transition from milk to a more solid diet is begun slowly by adding gradually soft cooked eggs, dry toast, baked potato, fish, or the white meat of chicken. Later, as the cardiac condition improves, more solid food is given, but never a large amount of food at any one meal, in order to avoid embarrassing the heart by a well-filled stomach.

Constipation.—In the ordinary type of constipation, due to sluggish action of the bowel, and not due to mechanical obstruction, it is advisable to give food which tends somewhat to irritate and stimulate peristalsis, such as oatmeal, whole wheat, vegetables, fruit, and a liberal amount of water.

In spastic constipation the diet is just the reverse of that employed in the atonic type. A bland, low-residue diet is given, beginning with one of the semiliquid or soft character. Later, the diet is increased to a soft, smooth-residue one.

Diarrhœa.—In the ordinary type of diarrhœa, due to an acute gastro-intestinal disorder, give bland nonirritating liquids for a diet, well-cooked and strained gruels, such as arrowroot, farina, and rice, and boiled milk. Later, as the condition improves, lean meat and fish, potatoes, simple extracts, and milk puddings may be added.

Diabetes.—The diet in diabetes is one in which carbohydrates and fats are regulated by the medical officer. It is given exactly as prescribed by the medical officer and it is essential that the patient should eat it entirely. Nor should he take any other food.

Gastric ulcer.—Lenhartz or Sippy diet or some similar diet is probably the most generally used. This consists of hourly feedings during the first 10 days of small amounts of milk and cream, between which feedings alkalies are given by mouth. Later the feedings are given at 2-hour intervals, and at the end of 4 or 5 weeks five or six feedings a day are given, with gradual addition of semisolids and later solid foods.

Long Island College Hospital ulcer diet is another diet successfully used in the treatment of gastric ulcers. It includes milk, toast, butter, cream, cooked

cereals, soft cooked eggs, cream cheese, simple desserts, stewed fruits, and lactose. It is served in meals three times a day with interfeedings.

Gout.—Prohibit food of glandular organs, such as sweetbreads, liver, kidneys, and all food rich in extractives, as well as acid and highly seasoned foods. The diet should consist principally of milk, cream, eggs, butter, farina, tapioca, cornstarch, extracts, ice cream, water ices, potatoes, and possibly a little boiled meat.

Nephritis.—In an acute attack with œdema, avoid condiments and salt in the diet and give bland, easily digested food with not more protein than is necessary to maintain the basal requirements, the balance of the diet being made up from carbohydrates and fats in sufficient amounts to maintain the caloric requirements of the individual. In some cases the Karell diet is recommended, consisting of 800 cc of milk a day, although it is not considered advisable to maintain the patient on this diet for any length of time.

In the chronic forms of nephritis this principle still holds, it being advisable to throw the minimum amount of work on the kidneys and to eliminate all irritating and highly seasoned dishes from the menu. The restriction of protein intake below that required for the actual body needs is inadvisable, as if insufficient protein is derived from the food the patient will make up the deficiency from his own tissues.

As regards the amount of water a patient with nephritis should take, it is not advisable to lay down any specific rule, as the amount which should be taken in each case depends upon the ability to excrete water, and this can be ascertained readily if the amount ingested and the amount excreted is measured daily.

Obesity.—In obesity, determine the number of calories the patient is to have each day, giving less, of course, than the amount required to maintain the weight of the patient. Ordinarily, if a patient is up and about and can combine a restricted diet with a certain amount of exercise, the efforts at reduction of weight will be much more effective. A diet containing 1,200 to 1,500 calories per day, together with exercise, such as walking 3 to 5 miles a day, usually will accomplish the desired result. If the patient is given foods of low caloric value such as the green vegetables, and items such as butter, cream, bread, and potatoes eliminated from the diet, he usually can get along without suffering inconvenience or severe hunger.

Fevers.—In fever the metabolic processes are increased and the power of assimilation is lowered. In order to maintain a fever patient properly the food should be easy to take, easy to digest, and readily assimilated. Milk is the almost universally used food in this condition, but must be supplemented by additional items. Cream is of great value owing to its high caloric content, and eggs also constitute a valuable addition to the diet. Meats ordinarily are not used in fevers, although the meat juices may be used occasionally. The balance of the diet may be made up from sugars and starches, and sufficient fluid should be supplied to keep the patient comfortable.

Tuberculosis.—The diet of the tuberculous patient should be ample, slightly more than the patient's calculated requirement. It should be well balanced and not lacking in vitamins, minerals, or roughage. Protein should be liberal but not excessive. Fats should be generous, and carbohydrates in normal proportions.

The food should be simple, easily digested, and well prepared. Some authorities believe food between meals is inadvisable because, as a rule, more will be eaten at meal times and with better enjoyment if there has been no interfeeding. Rest before and after meals is beneficial to the digestion.

CLASSIFICATION OF DIETS IN NAVAL HOSPITALS

The diets served in naval hospitals usually are liquid, soft, light, regular, and special diets.

Liquid diets are usually ordered as "clear liquid" or "full liquid." A clear liquid diet includes clear broths, rice and barley water, black tea or coffee, jello, and strained fruit juices. A full liquid diet includes all liquids served in a clear liquid diet with the addition of strained soups, strained gruels, milk and milk drinks, ice cream, and junket.

Soft diet includes all liquids in addition to well-cooked cereals, Italian pastes, white bread and crackers, soft-cooked eggs, cottage cheese, soft cream cheese, tender fish, chicken, minced tender lamb and beef, sweetbreads, and brains. Baked, mashed, escalloped, and creamed potatoes, and puréed vegetables are also given on a soft diet. The desserts used are custards, gelatin puddings, simple cakes and cookies, cooked fruits without seeds or heavy fiber, and ripe bananas.

Light diet includes all articles given in the soft diet as well as prepared cereals, whole-wheat bread, creamed or grated cheese, steaks, chops, bacon, tender roast lamb or beef, fish, and liver. The vegetables allowed, not puréed, are asparagus, peas, string beans, spinach, carrots, beets, squash, tomatoes, and lettuce. All cooked fruits, citrus fruits, olives, and mayonnaise are allowed.

Regular diet is the diet served to the general mess.

Special diets include the Lenhartz, Sippy, Karell, and other special dietaries which are indicated in some particular diseases and which are prescribed by the medical officer for some particular case.

SPECIAL METHODS OF FEEDING

Special methods of feeding include rectal feeding, duodenal alimentation, nutrient inunctions, intravascular injection, saline irrigations and saline infusions.

Nutrient enemata.—This is the term applied to the administration of food by rectum. With careful technique, a patient may be fed by rectum for a period of several weeks, although it is doubtful if more than one-sixth to one-fourth of the total caloric requirements can be supplied in this manner. The rectum first should be cleansed thoroughly by high injection of physiological salt solution an hour before the enema is to be given. This cleansing enema should be given at least once a day.

Nutrient enemata may be indicated in extremely weakened conditions when the quantity of food taken through the mouth is insufficient to maintain life; in obstruction of the pharynx or œsophagus, and in paralytic conditions of the pharynx when the patient is unable to swallow food; in diseases of the stomach, as in cancer with stricture and in delirious, comatose, or insane persons who cannot be fed by mouth.

In feeding by rectum it must be remembered that the large intestine has no power of digestion, apparently absorbs little besides water and salts, and there is but little possibility that food administered in this way will reach the small intestine where most of digestion takes place. Consequently in feeding by rectum only predigested foods or foods in an immediately absorbable form, such as dextrose solution, should be given.

The usual nutrient enema consists of milk, which has been pancreatized for 24 hours and boiled, about 8 ounces, to which may be added either 2 to 3 drams of dextrose, 2 to 3 drams of alcohol, 1 or 2 yolks of eggs, or a combination of all three.

The nutrient enema usually is given by the drop method and it is sometimes advisable to add 10 or 15 drops of tincture of opium as a sedative.

Duodenal alimentation.—This consists of feeding through a duodenal tube which has been introduced through the stomach and is a desirable way of feeding a patient in conditions in which the stomach needs a rest.

Nutrient inunctions.—Particularly if oils such as olive oil, cod liver oil, coconut oil, or cocoa butter are used, nutrient inunctions are sometimes of value, especially in infants suffering from marasmus or malnutrition.

Intravascular injection.—This consists in introducing fluid into a vein, usually in the form of salt, alkaline, and dextrose solutions. It usually is practiced as an emergency measure and not as a routine procedure.

Subcutaneous feeding.—This method of administration is somewhat unsatisfactory, but solutions of dextrose in physiological salt solution and also olive oil have been given in this manner.

Saline irrigation and infusion.—Saline irrigations by rectum are especially useful in such conditions as hæmorrhage and in various acute fevers when it is inadvisable to give fluids by mouth. They serve to allay thirst and are a very useful means of increasing the amount of fluid in the system. Saline infusion given subcutaneously is useful in cases where the patient cannot retain a rectal solution and usually is given in the chest, lumbar region, abdomen, or buttock.

RECIPES

Peptonized Milk (Warm process)

Put one-half cup (gill) of cold water and the powder contained in one peptonizing tube into a clean quart bottle and shake thoroughly; add a pint of cold fresh milk and shake again; then place the bottle in a pail or kettle of warm water at about 115° F., or not too hot to immerse the whole hand in it without discomfort. Keep the bottle in the water bath for 5 or 10 minutes, or longer if it is desired to peptonize the milk quite completely, then put it immediately on ice in order to check the process of digestion and keep the milk from spoiling. The container should be placed directly in contact with the ice.

The degree of peptonization is regulated very simply in this process by the length of time during which the milk is kept in the water bath. It is seldom necessary to peptonize milk until it becomes bitter.

In the following formulas for preparation of food for the sick, those marked with an asterisk (*) are quoted from "Dietetics for Nurses," by F. T. Proudfit:

* Orangeade

Juice of 1 orange.
1 tablespoonful sugar.
Juice of ½ lemon.
Enough water to fill the glass.

* Albuminized Orangeade

Make orangeade as directed in preceding recipe without the addition of water. Break the whites of two eggs into a saucer and with scissors cut the albumin until free from membrane and strain, stir this into the orange juice and add several pieces of cracked ice. This is both nourishing and palatable, and the taste of the egg cannot be detected.

Egg Nog

1 egg.
¾ tablespoonful sugar.
Speck of salt.
¾ cup milk.
Flavor with nutmeg.

Beat the egg, add the sugar and salt; blend thoroughly, add the milk and nutmeg. Serve immediately.

* Cocoa

2 teaspoonfuls cocoa.
½ teaspoonful sugar.
½ cup boiling water.
⅔ cup milk

Mix cocoa and sugar together and add boiling water slowly. Boil 3 to 5 minutes; heat milk in double boiler and add cocoa mixture. Beat with egg beater to distribute cocoa and prevent scum forming. Serve with or without whipped cream. Cocoa may be reinforced with albumin or the whole or yolk of one egg well beaten. If the white alone is used, care must be observed that the liquid is not hot enough to coagulate the albumin. Proprietary foods and casein preparations are used in like manner.

* Malted Milk Chocolate or Cocoa

1 tablespoonful malted milk.
1 tablespoonful cocoa or grated chocolate.
6 ounces milk.
2 ounces water.
½ teaspoonful sugar.
4–5 drops vanilla extract.

Mix cocoa or chocolate with water and boil 2 to 3 minutes. Pour milk into a double boiler and heat, mix malted milk with a little water and stir into the hot milk, add the cocoa paste, sugar, and vanilla, beat the mixture briskly to mix ingredients thoroughly, and serve with or without cream.

Chocolate Syrup

1 ounce (3 tablespoonfuls) chocolate.
1 cup boiling water.
1½ cups sugar.
1 tablespoonful of vanilla.

Put chocolate in a saucepan and add the water gradually, stirring all the time. Add sugar and stir until it begins to boil; boil 3 minutes, strain, cool, and add 1 tablespoonful vanilla. Bottle and keep in a cold place.

Chocolate Shake (Individual rule)

2 tablespoonfuls chopped ice.
2 tablespoonfuls chocolate syrup.
3 tablespoonfuls whipped cream.
½ cup milk.
¼ cup soda water or carbonated water.

Shake or stir well before drinking. A tablespoonful of vanilla ice cream is a desirable addition. It is a delicious drink, even if the soda or carbonated water is omitted.

A plainer drink is made by combining the syrup, three-fourths cup milk, and the ice, and shaking well.

* Coffee

2 tablespoonfuls ground coffee.
2 teaspoonfuls white of egg.
1 cup boiling water.
¼ cup cold (boiled) water.

Mix coffee with 1 tablespoonful of cold water and egg white in small pot (after scalding pot), add boiling water; allow to boil 3 minutes; stir down and add cold water; set pot where coffee will stay hot, but not boil, for 10 to 15 minutes, serve with cream and sugar or to flavor.

* Coddled Egg

1 egg
1 pint water.

Allow water to boil; wash egg; drop into boiling water and place saucepan where water will keep hot, but not boil; allow to stand 7 or 8 minutes. Serve with salt.

* Soft Cooked Egg

Proceed as for coddled eggs, but allow egg to remain from 10 to 15 minutes or even longer, if very soft eggs are not desired.

* Poached Egg

Have small, shallow saucepan half filled with boiling water or milk, if an egg poacher is at hand, use that; otherwise, lower a flat perforated spoon into water and place where the water cannot boil. Break the egg carefully into the spoon, taking care not to break the yolk; allow to stand in hot water until the white is of the consistency of jelly; lift out, slide egg on to hot toast, taking care not to break. (A broken poached egg is very unappetizing, as well as untidy in appearance).

Scrambled Egg

Wash an egg, break it into a small frying pan, add a teaspoonful of butter, 2 tablespoonfuls of milk, and pinch of salt and shake of pepper. Put over heat, and stir just enough to keep from sticking to pan. Allow mixture to become jellylike, remove, and serve on hot buttered toast.

Water Toast

Toast a slice of bread to golden brown, have about a pint of boiling water, put in a teaspoonful of salt. Dip the toast in boiling water and take it out again very quickly, then butter lightly, and serve at once. This form of toast can be used in case of sore mouth.

Milk Toast

Toast a couple of pieces of bread to golden brown. Put on 1½ cups of milk and bring to a scalding point. Add one-fourth teaspoonful salt. Butter the toast, cut in strips, and place in bowl. Pour on the scalding milk and serve.

* Baked Custard

1 egg.	¾ cup milk.
1 tablespoonful sugar.	A few drops of vanilla.

Beat eggs and sugar together, stir into milk, grease custard cup with butter, pour in the mixture. Set cup on several layers of paper in a deep pan, surround with hot water (to about half its depth). Set pan in moderate oven and allow to cook slowly until custard is firm in the center. It may be served hot or chilled, and turned out, with a tablespoonful of whipped cream on top.

Care must be taken not to allow the oven to get hot or the egg will coagulate, making a watery, unpalatable, and indigestible mixture.

* Soft Custard

1 egg (or 2 yolks).	1 cup milk.
1 tablespoonful sugar.	A few drops of vanilla.

Heat milk in double boiler. Beat egg and sugar together. When milk has reached the scalding point (small bubbles form around the edge of the saucepan), stir in the egg. Care must be taken not to allow the water under the saucepan to become too hot, as the custard will curdle if the egg is cooked at too high a degree of temperature. The custard must be stirred constantly in the beginning until it begins to thicken, then several times a minute until it is of the desired consistency and the raw taste is cooked out of the egg. This mixture is done when it will form a coating upon the spoon. Serve with whipped cream on top.

Beef Tea with Hydrochloric Acid

Select one-half pound of good beef; remove everything that is not clear meat. Chop it fine. Put in pint fruit jar and add 1 cup cold water and 5 drops diluted hydrochloric acid. Stir and set in refrigerator or any cold place for 2 hours to digest. Then strain, season with salt, and serve in dainty china cup on account of color. If one should object to color, heat the tea in a double boiler just till color changes. Do not strain. Beef tea made in this way is recommended by physicians for feeble children and patients much weakened by sickness.

Beef Juice

Select a piece of meat from the rump or top of the round. Remove all fat and broil or warm slightly 1 or 2 minutes, to set free the juices; lay on plate and cut meat in various directions that more juice may be extracted; then squeeze out the juice by means of a press, lemon squeezer, or potato ricer into a slightly warmed cup. Salt if necessary, and serve at once. Prepare only enough to serve, as it does not keep well. Serve in dainty china cup to disguise color. One pound of meat yields 4 ounces of juice.

Orange Jelly, (Individual rule)

1 teaspoonful granulated gelatin.	2 tablespoonfuls sugar.
1 tablespoonful cold water.	3 tablespoonfuls orange juice.
3 tablespoonfuls boiling water.	2 teaspoonfuls lemon juice.

Soak the gelatin in the cold water one-half hour; add the boiling water and dissolve. Add sugar and fruit juice, strain through a cloth and strainer into cold, wet mold.

Cocoa Junket (Individual rule)

1 tablespoonful cocoa.	¼ Junket tablet.
2 teaspoonfuls sugar.	1 teaspoonful cold water.
2 tablespoonfuls boiling water.	3 drops vanilla.
1 cup milk.	

Mix the cocoa, sugar, boiling water, and cook over heat and rub to a smooth paste; add gradually the fresh cool milk. Heat until lukewarm (not more), add vanilla and then tablet dissolved in the cold water. Pour mixture immediately into sherbet cups, partly full. Stand in warm room undisturbed until firm, like jelly, then put on ice to cool.

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CHAPTER VIII

PHARMACY

From the vegetable, mineral, and animal kingdoms of Nature are obtained the medicinal substances used for the alleviation of disease and for the restoring or the preserving of health.

Pharmacy is the science which treats of medicinal substances.

The study of pharmacy embraces not only a knowledge of medicinal substances and of the art of preparing, compounding, and dispensing them, but also of their identification, selection, preservation, combination, analysis, and standardization. The discovery of new medicinal drugs and the making of organic compounds are important functions of scientific pharmacy.

The word pharmacy is also used as the name of a place where medicines are sold, and it is derived from the Greek word *pharmacon*, meaning "a drug, a medicine."

For convenience in studying pharmacy, this science is divided into two major classes: Theoretical Pharmacy and Practical Pharmacy.

As all Nature is called upon to provide the remedies used in the healing art, it follows that the sciences which contribute to a thorough understanding of the vegetable, mineral, and animal substances used as medicines, and the sciences which treat of the laws governing them, furnish many of the important facts forming the basis of scientific pharmacy, and that a knowledge of those sciences is essential to theoretical pharmacy.

Theoretical pharmacy is that branch of pharmacy which treats of the substances used as medicines and of the laws governing them.

The following sciences comprise theoretical pharmacy:

Botany, the science of plants.

Mineralogy, the science of inorganic substances found in and on the earth.

Zoology, the science which treats of animals.

Physics, the science which describes and explains the changes produced in substances by which their original identity is not destroyed.

Chemistry, the science which treats of those changes produced in substances affecting or altering their original identity.

Materia medica, the science which treats of the medicinal materials used for cure or the prevention of disease.

Pharmacognosy, the science which treats of crude drugs.

Toxicology, the science which treats of poisons, their sources, effects, and antidotes.

Microscopy, the science of examining the minute structure of substances by the aid of the microscope.

Bacteriology, the science which treats of microörganisms.

Serology, the science which treats of serums.

Biology, the science which treats of life.

Pharmacodynamics, the science which treats of the action of drugs and their effects upon the various organs and functions of the body.

Pharmacology, the science which treats of the nature and properties of drugs.

Upon the sciences of physics and chemistry pharmacy is most dependent for its greatest development and for its highest degree of usefulness.

Practical pharmacy is that branch of pharmacy which treats of the operations, processes, and methods used in applying the principles of theoretical pharmacy. Practical pharmacy is sometimes known as operative pharmacy.

In the Navy the practice of pharmacy is concerned primarily with the compounding and dispensing of remedial agents according to the prescription of the medical officer or to the instructions given in authoritative texts. *Compounding* is the skillful blending of two or more ingredients. *Dispensing* is the transferring of a substance from one container to another for any one of several reasons. In civil life compounding and dispensing are the acts which legally distinguish the practice of pharmacy from the mere selling of drugs and remedies.

The principal books used in the study and practice of pharmacy are the United States Pharmacopœia, the National Formulary, dispensatories, and textbooks on the principles and practice of pharmacy.

The **United States Pharmacopœia** is an authoritative book containing a list of standardized medicinal substances, with descriptions, tests, and formulas for preparing them. The medicinal substances listed in it are recognized as official, and the word "official" as applied to a drug or preparation means that it is listed only in the Pharmacopœia. It was first published in the year 1820, by the doctors of the United States who before that time had no national standard for the medicines and preparations they were using. It has been revised every 10 years since 1820 and the present revision is known as the eleventh, abbreviated U. S. P. XI. The Pharmacopœia is owned, edited and revised by the United States Pharmacopœial Convention which is incorporated under the laws of the District of Columbia. This convention is made up of delegates appointed from the professions of medicine, dentistry, pharmacy, and chemistry.

The U. S. Pharmacopœia recognizes nearly all the drugs and preparations that are considered by the medical profession as essential in the treatment of the sick or in the prevention of disease. Exceptions are some of the valuable medicines of recent discovery and medicines whose composition or method of preparation is kept secret or that are controlled by patent rights. It establishes the official titles, abbreviation, dose, and synonym of each substance, and defines, describes, establishes the purity, gives tests for the identity, assay processes or methods for determining the strength, chemical formula, source in the case of animal and vegetable drugs, and instructions for the preservation of nearly all the medicines which it contains.

The Pharmacopœia is recognized by the Federal and State Governments in the enforcement of food and drugs acts as the standard for the articles listed therein when they are used for medicinal purposes only.

Medicinal substances of sufficient importance to be given a place in the Pharmacopœia are indicated by—

1. The official Latin title. Example: *Unguentum Phenolis.*
2. The official English title. Example: Ointment of Phenol.
3. The abbreviated title. Example: *Ung. Phenol.*
4. The synonym. Example: Ointment of Carbolic Acid.
5. The botanical name (in the case of plants). Example: *Capsicum frutescens.*
6. The symbolic formula (in the case of chemicals). Example: $Na_2SO_4.10H_2O$.

Latin, being universally used and understood as the language of science because it is a dead language and not liable to change, is selected for the official

title of the substances named in the Pharmacopœia. The official Latin titles of those substances are therefore distinctive and precise, and there is almost no possibility for error. The official English titles are used in ordinary conversation and in commercial transactions. The abbreviated titles provide uniformity in use and help to prevent mistakes in reading and compounding prescriptions. Synonyms are usually from old and unscientific sources but through common custom and long usage they have become so well established that they cannot be entirely ignored or abandoned. The botanical name is the name for plants that is recognized by botanists; it serves as the basis of the official name in the Pharmacopœia and its use is absolutely necessary in establishing the identity of any vegetable drug, for the Pharmacopœia names the particular variety of a plant that is recognized as official. The symbolic formula is a combination of certain arbitrary symbols used to briefly and exactly state the composition of a chemical.

The **Purity Rubric** was first introduced into the U. S. P. VIII to limit the quantity of permissible harmless impurities in chemicals, by stating in terms of percentage the amount of pure substance that must be present. Its use has been continued and extended to drugs and many other articles in the Pharmacopœia.

Doses are given in the Pharmacopœia in both the metric and apothecaries systems, but the figures are not interchangeable, nor are they to be considered as exact equivalents. Under the term *average dose* are stated the doses which may be expected ordinarily to produce the therapeutic effect for which the preparation is most commonly employed. The doses when administered orally are those for human adults, unless otherwise indicated. The method of administration is named whenever necessary.

The **National Formulary** is a book containing a list of extensively used drugs and preparations that are not included in the Pharmacopœia. The medicines which it contains are recognized because of their extensive medicinal use and pharmaceutical soundness, rather than their therapeutic value. A drug to be recognized by the Pharmacopœia must not only be extensively used, but it must also have well-recognized therapeutic properties, or be used in the preparation of some other medicine in the Pharmacopœia. A drug to be recognized by the National Formulary, however, need only be extensively used and pharmaceutically sound. This difference makes the National Formulary a book of secondary importance to the Pharmacopœia.

Many of the drugs and preparations listed in the National Formulary were at some time contained in the Pharmacopœia, and, as they were dropped from time to time, the National Formulary took them up, because they were still used by many members of the medical profession in different parts of the country, and because they were extensively used, it was necessary there should be some standard by which they could be prepared.

The National Formulary is owned, edited, and revised by the American Pharmaceutical Association. It is revised every 10 years, usually following the revision of the Pharmacopœia. In the last revision the policy of adopting only those preparations and drugs cast aside by the Pharmacopœia was discontinued.

It is recognized by the Federal and State Governments in the enforcement of the food and drugs acts as the standard for the articles listed therein when they are used for medicinal purposes only.

A **Dispensatory** is a commentary on the United States Pharmacopœia, the National Formulary, the pharmacopœias of other countries, and, in addition, contains information about most of the substances that have been or are now

used in the cure or prevention of disease. It is an excellent reference book for one studying pharmacy or medicine, as it gives a complete description of the physical, medical, and pharmaceutical history of medicinal substances, their preparation and properties, constituents and compounds, uses, action and doses, tests and assays, etc.

METROLOGY

Metrology is the science of weights and measures, and treats of the measures of length, surface, volume, and weight. The word is derived from Greek words meaning measure and discourse.

Weight is defined as the difference between the attraction of the earth and that of surrounding bodies for bodies on the surface of the earth. The weight of a body depends upon its bulk and density, density being the amount of matter in a given bulk of the body.

Weighing is the balancing of a body of known gravitating force with one whose gravity is not known in order to estimate and determine the gravitating forces of the latter, which is called its weight.

Weights are bodies of known gravitating force used for weighing. The apparatus used for weighing are scales or balances and weights. Weights are based upon standards known as the *grain* and the *meter*.

The weights and measures in general use in the United States are *avoirdupois*, used in commercial buying and selling; *troy*, used by jewelers; *apothecaries*, used by pharmacists in compounding; and *metric*, used almost entirely in scientific work and research.

The *grain* weight was established by King Henry III of Great Britain in 1266 in an act in which he decreed in part that "An English silver penny called the sterling, round and without clipping, shall weigh 32 grains of wheat, well dried and gathered out of the middle of the ear." This statute was reiterated by Edward I in 1304.

The *metric* system of weights and measures has for its fundamental unit the meter, which is the distance equal to one ten-millionth part of a quadrant of longitude running through Paris, France. The length of the meter is usually defined as the one forty-millionth part of the circumference of the earth around the poles.

The *metric* system of weights and measures, also known as the French and the decimal system, originated in France as a result of suggestions that there be a standard for scientific measurements. The French Assembly in 1790 appointed commissions to study and report on such a standard and these commissions decided upon the meter as the unit of length, drew up a system of weights and measures based on the length of the meter, and fixed the nomenclature. The system of weights and measures and the nomenclature were established by law in 1795 but it was not until 1799 that the report on the length of the meter was made. On December 10, 1799, a law definitely fixed the value of the meter and of the kilogram, or weight of a liter of water.

Use of this system has been adopted by nearly all countries but has never been made compulsory in the United States where, however, its use was legallized by an Act of Congress passed in 1866 which also directed its use in the medical department of the Army and Navy and the Marine hospital service. The Secretary of the Navy in 1878 directed that this system be used in the Medical Department of the Navy and its use has also been adopted by many scientific bodies in this country.

In Paris, France, there are preserved the models of the meter and kilogram from which all prototypes are made. Since 1875 there has been in Paris, France, an International Bureau of Weights and Measures managed by an

International Committee composed of representatives of all civilized nations. This committee makes and provides prototypes of the model meter and kilogram for the subscribing nations.

The United States prototypes, made of a platinum-iridium alloy, are kept in the Bureau of Standards at Washington, D. C. and are used for standardizing *all* the weights and measures used in the United States.

The denominations of this system are multiplied by the Greek words *deka*, meaning ten; *hecto*, meaning hundred; and *kilo*, meaning thousand, and are divided by the Latin words *deci*, meaning one-tenth; *centi*, meaning one-hundredth; and *milli*, meaning one-thousandth.

The *metric* system is divided into four branches but only three of these are ordinarily used in pharmacy. They are the measures of length, of volume or capacity, and of weight.

The unit of length is the *meter*, which is the one forty-millionth part of the circumference of the earth around the poles and is equivalent to 39.37 inches. The unit of volume or capacity is the *liter*, which is the volume of one cubic decimeter. It is also defined as the volume occupied by the mass of 1 kilogram of distilled water at its maximum density (4° C.). It is equivalent to 2.1134 pints. The unit of weight is the *gram*, which is the weight of one milliliter of distilled water at its maximum density (4° C.). It is equivalent to 15.432 grains.

The unit of microscopic measurement is the *micromillimeter*, or *micron*, which is a thousandth part of a millimeter.

The denominations most commonly used in pharmacy are the *kilogram*, the *gram*, the *milligram*, the *liter*, and the *milliliter*. Metric prescription weights are usually supplied in two denominations, the *gram* and the *milligram*. Nearly all small graduates are graduated in *mils* or *milliliters* (another name for the *milliliter* is *cubic centimeter*, abbreviated cc) and measures of more than 1,000 mils capacity are usually graduated in *liters*. The volume of one cubic centimeter was officially adopted for general use as the capacity unit in the U. S. P. XI, which states that 1 liter equals 1000.027 cc, and that 1 Gm. of water at 4° C. measures 1.000027 cc. Use of "cc" instead of "mil" is therefore correct.

The conversion of ordinary weights or measures into metric weights or measures and vice versa is not difficult and involves only simple mathematical procedures and the use of the figures given in the next paragraphs.

To convert metric weights or measures into those in ordinary use multiply the metric quantities by the corresponding equivalent. Therefore, to convert:

Meters into inches, multiply by 39.370.
Liters into fluidounces, multiply by 33.815.
Grams into grains, multiply by 15.432.

To convert the weights or measures in ordinary use into metric weights or measures multiply the quantities by the corresponding equivalent. Therefore, to convert:

Inches into meters, multiply by 0.0254.
Fluidounces into milliliters, multiply by 29.572.
Grains into grams, multiply by 0.0648.

The avoirdupois ounce contains 437.5 grains, the apothecaries 480, and the weight of 1 fluidounce of distilled water is 454.6 grains. In the avoirdupois pound there are 7,000 grains and in the apothecaries 5,760.

A gallon contains 231 cubic inches.

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The table of equivalents of weights and measures immediately following is given in order that the student may become familiar with the relations existing between the different systems.

Equivalents of Weights and Measures

English System		Metric Equivalent
Avoirdupois weight:		
1 grain	gram	0.0648
437.5 grains make 1 ounce (oz.)	grams	28.35
16 ounces make 1 pound (lb.)	do	453.60
100 pounds make 1 hundredweight (cwt.).		
20 hundredweight make 1 ton.		
Apothecaries weight:		
1 grain	gram	0.0648
20 grains make 1 scruple (℈)	grams	1.30
3 scruples make 1 dram (ʒ)	do	3.90
8 drams make 1 ounce (℥)	do	31.103
12 ounces make 1 pound	do	373.236
Troy weight:		
1 grain	gram	0.0648
24 grains make 1 pennyweight (dwt.)	grams	1.555
20 pennyweights make 1 ounce	do	31.103
12 ounces make 1 pound	do	373.236
Apothecaries measure:		
1 minim (0.95 grain) (♏)	cubic centimeter	0.06
60 minims make 1 fluidram (fʒ)	do	3.70
8 fluidrams make 1 fluidounce (f℥)	do	29.57
16 fluidounces make 1 pint (O)	do	473.18
8 pints make 1 gallon (Cong.)	do	3,785.40
Linear measure:		
1 inch	millimeters	25.4
12 inches make 1 foot	centimeters	30.48
3 feet make 1 yard	meter	0.914
5.5 yards make 1 rod (or perch).		
40 rods make 1 furlong.		
8 furlongs make 1 mile	do	1,609.35

Metric System		English Equivalent
Length:		
Kilometer, 1,000 meters	mile	3/5
Hectometer, 100 meters.		
Decameter, 10 meters.		
Meter (unit)	inches	39.37
Decimeter, one-tenth meter	do	3.937
Centimeter, one-hundredth meter	do	2/5
Millimeter, one-thousandth meter	do	1/25
Capacity:		
Kiloliter, 1,000 liters.		
Hectoliter, 100 liters.		
Decaliter, 10 liters.		
Liter (unit), cube of one-tenth meter	fluidounces	33.814
Deciliter, one-tenth liter	do	3.3814
Centiliter, one-hundredth liter	do	1/3
Milliliter, one-thousandth liter (ml)	minims	16.23
Weight:		
Kilogram, 1,000 grams	apothecaries ounces	32.15
	avoidupois ounces	35.27
Hectogram, 100 grams.		
Decagram, 10 grams.		
Gram (unit)	grains	15.432
Decigram, one-tenth gram	do	1.5
Centigram, one-hundredth gram	do	1/6
Milligram, one-thousandth gram	do	1/65

Approximate measures

	Apothecaries	*Metric*
A tumblerful	f℥viii	240 cc
A teacupful	f℥iv	120 cc
A wineglassful	f℥ii	60 cc
A tablespoonful	fʒiv	16 cc
A dessertspoonful	fʒii	8 cc
A teaspoonful	fʒi	4 cc

Balances and measures.

A balance is an instrument for determining the relative weights of substances, or, for weighing. If accurate results are to be obtained in the use of a balance it must be correctly constructed, skillfully used, and carefully protected from injury. A balance is frequently called a scales, a term whose use is not desirable.

Pharmaceutical balances may be classified according to the type of their construction as: 1. *Single beam, equal arm;* 2. *Single beam, unequal arm;* 3. *Double beam, unequal arm;* 4. *Compound lever balance;* and 5. *Torsion balance.* Of these, the types most commonly used in pharmacy are the single beam, equal arm, and the torsion balance. In analytical work the balance used has to be much more sensitive than the average pharmaceutical or prescription balance and great care and accuracy is required in its construction. One type of analytical balance is called the Chainomatic balance.

In the construction of the single beam, equal arm balance, a beam is suspended on a knife-edge, which divides it into equal arms, and knife-edges are placed at each end of the beam on the same plane and at exactly equal distances from the point of suspension to support the pans which carry the substances to be weighed. The construction of the single beam, unequal arm balance can be seen by inspecting the well-known Fairbanks scales. This type of balance depends on the principal in physics: "The power is to the weight or resistance in the inverse ratio of the arms of the lever." The longer arm of the beam is graduated for a movable weight, the use of which dispenses with small weights and is a decided advantage.

In the double beam, unequal arm balance the construction is the same as given before, but with two parallel beams, and is employed for weighing liquids, etc., the outside beam being used to tare the bottle or jar.

A compound lever balance is well shown in Fairbanks platform scales. It is used on druggists' counters and sometimes for prescription scales.

A torsion balance is one in which a compound beam is balanced and supported upon an immovable frame. The beam is prevented from slipping out of place, and the torsion is secured by a flattened steel wire or spring stretched upon the center frame and firmly fastened to the underside of the beam. Upon the ends of the beam are fastened the movable frames which support the pans. Motion of the beam may be arrested easily by moving the lever, and the delicacy of the balance is increased by placing a weight upon the index, whereby the center of gravity is elevated. In this type of balance knife-edges are done away with entirely.

Care of a balance.—A balance should be kept in a closed case in a dry place protected from corroding vapors. The balance and scale pans should not be polished with gritty substances but should be cleaned with chamois. Steel knife edges should be coated with a very thin coating of vaseline. The beam should not be left in an oscillating position when the balance is not being used. Weights should be put on and taken off with pincers. The substance to be weighed should be placed in the left-hand pan (the pan to the left of the operator as he faces the balance) and the weights in the right-hand pan. The first step in weighing is to see that the balance is balanced, and that the knife edges are in position; then place a piece of pan-paper in each pan, and see that the balance is balanced after the paper has been placed in the pans. Put the weights in the right-hand pan, and carefully place enough of the drug in the left-hand pan to exactly balance the weights. After removing the drug, check the weights to see that the amount is right, put the weights away, and clean up the balance. In weighing substances that injure the scale pans, by their chemical action, always use glass pans or waxed paper.

The **weights** used in pharmaceutical weighing are constructed of brass or aluminum. In the construction of metric weights, the gram weights are made of brass, lacquered to prevent oxidation, and the milligram weights are made of aluminum because it is a light metal and gives bulk to the small weights.

In the construction of apothecaries weights, all weights including and above the scruple are made of brass, and the grain weights are made of aluminum.

Measures.—Liquids are measured by the use of graduated vessels of tinned copper or iron, agateware, and glass. For use in the practice of pharmacy glass measures are preferable, vessels of the other materials usually being used in measuring quantities larger than 1 pint. To measure small quantities of liquids, such as minims, glass vessels known as pipettes often are used because of the assurance of accuracy.

Pipettes are glass tubes with a constricted point and graduated on the side. They are used by applying suction to the upper end and holding the liquid in the tube by placing the finger on the upper end while reading off the contents. Owing to capillary attraction, the top of the liquid in a graduated pipette presents a cup shape. This is called a *meniscus.* A line drawn through the bottom of the meniscus of transparent and the top of opaque liquids usually is selected as the reading point.

A drop, through error, is supposed to be a minim; but though this may be approximately true when applied to water, a drop and a minim are rarely the same. This fact must be kept in mind when administering medicines or when compounding from formulas and prescriptions that call for minims or for drops. Thick viscous liquids produce large drops; heavy mobile liquids small ones. A drop of syrup of acacia is five times as large as a drop of chloroform. The size of a drop depends also upon the shape of the vessel from which dropped, upon the form of the lip, upon adhesion, cohesion, rapidity of flow, and viscosity. A drop of liquid from a curved medicine dropper is larger than one from a straight dropper having the same sized opening, because the straight one generally is held at an angle so that the drop falls from one side of the orifice, but with a curved dropper the drop falls from the whole circle of the orifice. The table following shows the variation in the number of drops for several liquids when a standard dropper having an exit with an external diameter of 3 millimeters which will discharge 20 drops of water of such size that they will weigh 1 Gm. is used.

NUMBER OF DROPS OBTAINED FROM A STANDARD DROPPER

As recommended by the Brussels Conference, temperature 15° C. or 59° F.

Liquid	Drops per gram	Drops per cc	Drops per fluidram	Drops per minim
Distilled water	20. 0	22. 2	81. 5	1. 36
Hydrochloric acid	19. 5	23. 8	88. 0	1. 46
Nitric acid	22. 9	40. 0	148. 0	2. 46
Alcohol	65. 5	50. 0	185. 0	3. 10
Chloroform	58. 8	100. 0	370. 0	6. 16
Creosote	37. 4	45. 5	160. 0	2. 70
Ether	90. 0	66. 5	246. 0	4. 10
Fluidextract of ergot	52. 6	50. 0	185. 0	3. 10
Glycerin	23. 1	33. 3	123. 0	2. 05
Oil of santalwood	41. 5	50. 0	185. 0	3. 10
Phenol, liquefied	35. 5	40. 0	148. 0	2. 46
Solution of potassium arsenite (Fowler's solution)	21. 1	22. 2	81. 5	1. 36
Solution of potassium iodide, 50 per cent	18. 7	28. 6	106. 0	1. 76
Spirit of nitrous ether	65. 5	59. 0	218. 0	3. 63
Tincture of aconite	56. 3	50. 0	185. 0	3. 10
Tincture of digitalis	48. 1	50. 0	185. 0	3. 10
Tincture of ferric chloride	53. 3	55. 5	205. 0	3. 41
Tincture of hyoscyamus	50. 8	50. 0	185. 0	3. 16
Tincture of opium	50. 9	50. 0	185. 0	3. 10
Tincture of nux vomica	57. 3	50. 0	185. 0	3. 10
Tincture of iodine	63. 3	66. 5	246. 0	4. 10

Specific Gravity (abbreviated sp. gr.) is the weight of one body compared with the weight of an equal bulk or volume of another body selected as the standard, both bodies having the same temperature, or the temperature of each being

definitely known. The substance taken as a standard is *distilled water* for solids or liquids, and *air* for hydrogen or gases. Example: If at a certain temperature 1 cc of distilled water (the standard) weighs 1 Gm., and 1 cc of mercury at the same temperature weighs 13.5 Gms., the specific gravity of the distilled water is 1.000 and the specific gravity of the mercury is 13.500.

Methods by which specific gravity may be taken are:

1. By the specific-gravity bottle (pycnometer).
2. By the use of Lovi's beads.
3. By the use of the Westphal specific-gravity balance.
4. By the use of hydrometers (urinometer, lactometer, alcoholometer, saccharometer, etc.).

Because of certain physical characteristics solids are grouped under the following heads when their specific gravity is taken:

1. Solids insoluble in, and heavier than water.
2. Solids soluble in, and heavier than water.
3. Solids insoluble in, and lighter than water.
4. Solids soluble in, and lighter than water.

A different procedure is necessary when taking the specific gravity of a solid belonging to one of these groups.

As the weights of bodies are proportionate to their masses, and as the amount of matter in, or the mass of, a given bulk of a body is termed its *density*, it is evident that the specific gravity of a substance is equivalent to its density. Consequently the term density is frequently used in place of specific gravity.

The specific gravity, or density, of a substance has a direct bearing on its purity, and therefore specific gravity is made use of in determining the strength or purity of drugs and preparations. In the Pharmacopœia and in the National Formulary, under the description of a drug the specific gravity is frequently stated, especially when it would be of value in determining the strength or purity of the substance. The strength of alcohol, ammonia water, nitric acid, sulfuric acid, or hydrochloric acid can readily be determined by taking their specific gravity. Specific gravity tables for some substances have been worked out and are printed in the Pharmacopœia.

Specific Volume (abbreviated sp. vol.) is the volume of one body compared with the volume of an equal weight of another body selected as the standard, both bodies having the same temperature. Example: If, at a certain temperature, 100 cc of alcohol weighs 82 Gms., and the same weight of distilled water at the same temperature measures 82 cc, the specific volume of the alcohol will be as the volume of the alcohol (100 cc) is to the volume of the distilled water (82 cc). Dividing 100 by 82 gives 1.22, which is the specific volume of the alcohol.

Specific volume is directly the opposite of specific gravity for, while specific gravity deals with what weight of a certain substance will go into a certain sized bottle, specific volume asks what sized bottle will hold a certain weight or amount of that substance.

PHARMACEUTICAL ARITHMETIC

The rules of arithmetic apply to problems in pharmacy in exactly the same way as they apply to any other practical use of arithmetic. In pharmaceutical arithmetic accuracy is absolutely necessary, for an incorrect calculation or the misplacing of a decimal point can mean the difference between life and death.

Addition, subtraction, multiplication, division, fractions, decimals, percentage, ratio, and proportion all find their uses in the arithmetic of pharmacy.

A brief explanation of how to prepare solutions and mixtures of different strengths will now be given.

The strength of a solution or mixture is the proportion of active substance or drug to the solvent, vehicle or base, and is usually expressed in one of two ways: 1. By the percentage method; or 2. By the ratio method. The percentage method will first be considered.

Percentage means parts per 100 parts. In pharmaceutical and chemical problems percentage refers to parts by weight unless parts by volume is specifically stated. In the Pharmacopœia and in the National Formulary the term "per cent" is frequently used in stating the purity standard of the drug or preparation, preceded by a number. There also it refers to parts by weight unless parts by volume is specifically stated.

Percentage solutions, for convenience in preparation and administration, are divided in the Pharmacopœia into three classes: Weight in weight (w/w) solutions; Weight in volume (w/v) solutions; and Volume in volume (v/v) solutions.

A weight in weight percentage solution is one containing in every 100 Gms. of finished solution, the number of grams of the drug corresponding to the percentage strength. Thus a 5 per cent (w/w) solution of cocaine hydrochloride in water contains in every 100 Gms. of solution 5 Gms. of cocaine hydrochloride and 95 Gms. of water. It must be clearly understood that 100 Gms. of a weight in weight solution does not always measure 100 cc; in some cases it may measure more than 100 cc, but usually it will measure slightly less than 100 cc.

The only absolutely accurate type of percentage solution is the weight in weight but because of certain disadvantages it is not prepared as often as the weight in volume type. It is difficult to prepare a weight in weight solution because it is necessary to weigh the liquids used in its preparation which makes it impracticable in dispensing, especially when liquids other than water are used as solvents. Because of the contraction in volume that takes place in making solutions it is necessary to make more than the volume called for and results in a waste of the drug. In administering such solutions it is not a simple matter to calculate the amount of drug contained in a teaspoonful or in a certain number of cc. Because of these disadvantages the weight in volume and the volume in volume types of percentage solutions are much more popular.

A rule for determining the amount of drug and the amount of solvent to be used in making a stated number of grams of a weight in weight (w/w) solution is: *Rule.*—Multiply the number of grams of solution desired by the per cent expressed as a whole number; divide the product by 100; and the quotient will be the number of grams of drug required; subtract this from the number of grams of finished solution, and the remainder will be the number of grams of solvent to use. Instead of expressing the per cent as a whole number and dividing by 100, a common practice is to express the per cent decimally (0.05 for 5 per cent), multiply, and use the product as shown before. *Problem.*—Make 100 Gms. of 5 per cent (w/w) solution of silver nitrate in water. One hundred multiplied by 5 equals 500; 500 divided by 100 equals 5; and 100 minus 5 equals 95; or, 100 multiplied by .05 equals 5, and 100 minus 5 equals 95. *Answer.*—Dissolve 5 Gms. of silver nitrate in 95 Gms. of water. The finished solution will weigh 100 Gms. but will measure slightly less than 100 cc.

A weight in volume (w/v) percentage solution is one containing in every 100 cc of finished solution the number of grams of drug corresponding to the percentage strength. Thus a 5 per cent weight in volume (w/v) solution of silver nitrate contains in every 100 cc of finished solution 5 Gms. of silver nitrate and enough solvent to make 100 cc of solution.

As liquids are administered by volume instead of by weight it is easier to calculate doses, or the amount of drug contained in a given volume of a solution, if the strength of the solution is expressed in grams of solid or cc of liquid drug in every 100 cc of solution. The uniform relation between the milliliter (cc) and the gram in the metric system makes calculations very simple in preparing such solutions. This is the type of solution that is usually desired when a percentage solution is called for.

A rule for determining the amount of drug and the amount of solvent to be used in making a stated number of cc of a weight in volume percentage solution is: *Rule.*—Multiply the number of cc of solution desired by the per cent expressed as a whole number; divide the product by 100 and the quotient will be the number of grams of drug required. To this is added enough solvent to make the desired number of cc of finished solution. *Problem.*—Make 75 cc of a 5 per cent (w/v) solution of silver nitrate in water. Seventy-five multiplied by 5 equals 375; 375 divided by 100 equals 3.75. *Answer.*—Dissolve 3.75 Gms. of silver nitrate in enough water to make 75 cc of finished solution.

A volume in volume (v/v) percentage solution is one containing in every 100 cc of finished solution the number of cc of liquid drug corresponding to the percentage strength. Thus a 5 per cent (v/v) solution of glycerin in water contains in every 100 cc of finished solution 5 cc of glycerin and enough water to make up the volume to 100 cc.

A rule for determining the amount of drug and the amount of solvent to be used in making a (v/v) percentage solution is: *Rule.*—Multiply the number of cc of solution desired by the per cent expressed as a whole number; divide the product by 100; the quotient will be the number of cc of drug required. To this is added enough solvent to make the desired number of cc of finished solution. *Problem.*—Make 500 cc of a 3 per cent (v/v) solution of glycerin in water. Multiplying 500 by 3 equals 1,500; dividing 1,500 by 100 gives 15. *Answer.*—Measure out 15 cc of glycerin and to it add enough water to make 500 cc of finished solution.

In making percentage mixtures of solid or semisolid substances the weight in weight (w/w) percentage method is used. *Problem.*—Make 2,000 Gms. of an ointment containing 10 per cent of sulfur, using benzoinated lard as a base. How much sulfur and how much benzoinated lard is required? Multiplying 2,000 by 10 equals 20,000; dividing 20,000 by 100 gives 200; and 2,000 minus 200 equals 1,800. *Answer.*—Use 200 Gms. of sulfur and 1,800 Gms. of benzoinated lard to make the ointment.

It is often desired to know the percentage strength of a solution or a mixture made according to a formula or prescription. A simple rule for determining the percentage strength of a solution or a mixture is: *Rule.*—Multiply the number of grams (or cc in the case of a volume in volume solution) of active drug used by 100 and divide the product by the number of grams (cc in the case of weight in volume solution or a volume in volume solution) of solution or of mixture. *Problem.*—What is the percentage strength of a solution that contains 2 Gms. of cocaine in 50 Gms. of solution? Two multiplied by 100 equals 200; 200 divided by 50 equals 4. *Answer.*—Four per cent. *Problem.*—What is the percentage strength of an ointment that contains 1 Gm. of yellow oxide of mercury in 30 Gms. of the ointment? One multiplied by 100 equals

100, which, divided by 30 equals 3.33. *Answer.*—Three and thirty-three hundredths or $3\frac{1}{3}$ per cent.

In arithmetic ratio is the expression of the relation or of the comparison of two quantities. The two quantities compared are called the terms of the ratio. In the ratio 8 to 16, 8 is called the first term or antecedent and 16 the second term or consequent. Ratio is that number by which the second term must be multiplied to produce the first. As in any comparison, the two terms of a ratio must be of the same denomination before the relation between them can be found.

A ratio may be expressed in three ways: By the sign of division (8÷16); by a fraction ($\frac{8}{16}$); or by a colon (8:16). The value of a ratio is found by dividing the first term by the second term, and if the answer is a fraction it is reduced to its lowest terms. *Problem.*—What is the ratio of 2 yards to 4 feet. Two yards equals 6 feet; 6 feet:4 feet equals 6:4 equals $\frac{6}{4}$ equals $\frac{3}{2}$ equals $1\frac{1}{2}$. *Answer.*—The ratio of 2 yards to 4 feet or 6 feet to 4 feet is $1\frac{1}{2}$.

In the ratio method of expressing the strength of a solution the strength is expressed by stating the number of grams of solution (w/w) that contain 1 gram of the drug; the number of cc of solution (w/v) that contain 1 gram of the drug; or the number of cc of solution (v/v) that contain 1 cc of the drug.

A 1 in 10 (sometimes written 1–10) weight in weight solution contains 1 gram of drug in every 10 grams of finished solution. A 1 in 10 weight in volume solution contains 1 Gm. of the drug in every 10 cc of finished solution. A 1 in 10 volume in volume solution contains 1 cc of the drug in every 10 cc of finished solution.

Ratio solutions are usually prepared in strengths as follows: 1–10, 1–20, 1–50, 1–100, 1–200, 1–500, 1–1,000, etc., using round numbers to simplify calculations.

A rule for determining the amount of drug and the amount of solvent to be used in making a stated number of grams of a weight in weight solution by the ratio method is: *Rule.*—Divide the number of grams of solution desired by the larger number of the ratio and the quotient will be the number of grams of the drug to be used; subtract the number of grams of the drug from the number of grams of finished solution and the remainder will be the number of grams of solvent to use.

A rule for determining the amount of drug and the amount of solvent to be used in making a stated number of cc of a weight in volume solution is: *Rule.*—Divide the number of cc of solution desired by the larger number of the ratio; the quotient will be the number of grams of the drug to be used, and to this is added enough solvent to make the desired number of cc of finished solution.

A rule for determining the amount of drug and the amount of solvent to be used in making a stated number of cc of a volume in volume solution by the ratio method is: *Rule.*—Divide the number of cc of solution desired by the larger number of the ratio; the quotient will be the number of cc of the drug to be used and to this is added enough solvent to make the desired number of cc of finished solution. *Problem.*—Make 500 cc of a 1–20 (v/v) solution of glycerin in water. Five hundred divided by 20 equals 25; take 25 cc of glycerin and to it add enough water to make 500 cc of finished solution.

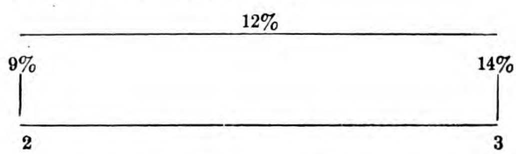
Alligation, or "the rule of mixtures," is an arithmetical rule relating to the solution of problems concerning the compounding or mixing of different ingredients, or ingredients of different qualities or values, and is so named from the method of connecting together the terms in a problem by lines.

It is made use of in pharmacy to determine the amounts of two or more strengths of a given substance needed to blend into a new, intermediate

strength of that substance. It is also applied in making adjustments of percentage or ratio strengths, and of specific gravities.

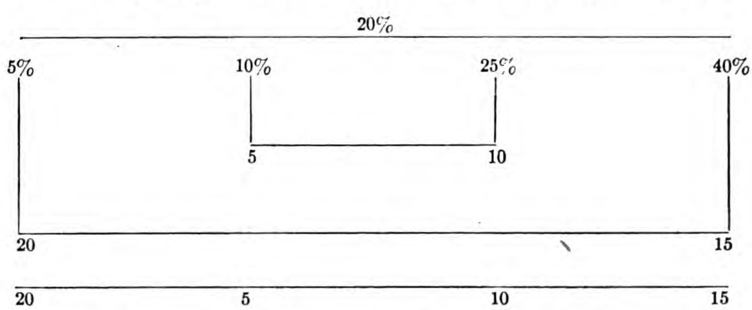
When the different strengths of a substance to be blended and the new strength of that substance are expressed in terms of percentage, the following is the procedure undertaken in determining the quantities of the different strengths at hand required to produce the new strength desired: Draw a horizontal line and above the center of it write the new or desired percentage; below the same line write the different percentage strengths of the substances to be mixed and draw a short vertical line downward from each; with a horizontal line link together the line below each percentage figure that is greater than that desired with one that is less; draw another horizontal line below the lines linking the percentage figures together and below this last line write the differences between the desired percentage and the percentages given, placing the difference for a lesser percentage under the greater percentage with which it is linked and the difference for a greater percentage under the lesser percentage with which it is linked. The numbers placed below the lowest line will be the numbers of parts by weight of each strength to be used in making a mixture having the new or desired strength. It must be remembered to *always link together a quantity which is less with one which is greater than the desired percentage.*

A simple problem in which it is desired to know how many parts of a 9 per cent mixture and of a 14 per cent mixture would be required to make a 12 per cent mixture would be expressed thus:



Nine is subtracted from 12, leaving 3, which figure is placed under the 14, and 12 is subtracted from 14, leaving 2, which figure is placed under the 9; therefore it takes 2 parts of a 9 per cent mixture and 3 parts of a 14 per cent mixture to make 5 parts of a 12 per cent mixture.

It is desired to know in what proportions four solutions of silvol containing 5, 10, 25, and 40 per cent (w/w) respectively would have to be mixed to obtain a solution containing 20 per cent of silvol. Express the problem thus:



By subtracting 5 from 20, 20 from 40, 10 from 20. and 20 from 25, it is found that it will take 20 parts of 5 per cent, 5 parts of 10 per cent, 10 parts of 25 per cent, and 15 parts of 40 per cent solutions of silvol to produce a 20 per cent solution, and as these are w/w solutions the parts represent grams of the solutions. By adding the lowest row of figures it is found that there would be 50 Gms. of the 20 per cent solution of silvol. The problem

may be proved as follows: Multiply the numbers of parts used by the percentages, add the columns of parts and answers, and divide the larger by the smaller. The result of this division should be the percentage desired if the operations are correct.

$$\begin{array}{rl} 20\times 5= & 100 \\ 5\times 10= & 50 \\ 10\times 25= & 250 \\ 15\times 40= & 600 \\ \hline 50 &)1000(20 \\ & 100 \\ \hline & 0 \\ & 0 \end{array}$$

It is desired to make 500 Gms. of a 20 per cent (w/w) solution from the solutions of different strengths previously named; what quantities of each solution will be required? As it has been found by alligation that a total of 50 parts of the solutions of different strengths are required to make a 20 per cent solution, to make 500 Gms. of the 20 per cent solution will require the use of $\frac{20}{50}$ of 500 Gms. or 200 Gms. of the 5 per cent solution, $\frac{5}{50}$ of 500 Gms. or 50 Gms. of the 10 per cent solution, $\frac{10}{50}$ of 500 Gms. or 100 Gms. of the 25 per cent solution, and $\frac{15}{50}$ of 500 Gms. or 150 Gms. of the 40 per cent solution. Following is the proof that these quantities are correct:

$$\begin{array}{l} \frac{20}{50} \text{ of } 500=\frac{10000}{50}=200 \\ \frac{5}{50} \text{ of } 500=\frac{2500}{50}=\ \ 50 \\ \frac{10}{50} \text{ of } 500=\frac{5000}{50}=100 \\ \frac{15}{50} \text{ of } 500=\frac{7500}{50}=150 \\ \hline \frac{50}{50} \text{ of } 500=\frac{25000}{50}=500 \end{array}$$

Reducing the fractions in the left hand column to decimals and then multiplying the amount of the 20 per cent solution to be made by them will also give the quantities of the different strength solutions to be used.

The problem can also be solved by the use of proportion, that process in arithmetic known as the equality of ratios or the relation between quantities. A ratio consists of two terms; a proportion of four. In a proportion the two outside terms are called the extremes and the two inner terms are called the means. In the proportion 8:4::160:80, 8 and 80 are the extremes, and 4 and 160 are the means. This proportion is read: 8 is to 4 as 160 is to 80.

In a proportion the product of the extremes is equal to the product of the means, and for the proportion given 8×80 equals 4×160 or 640 equals 640.

If one of the extremes in a proportion is missing, it can be found by dividing the product of the means by the extreme given, and likewise, if one of the means is missing, it can be found by dividing the product of the extremes by the given mean. The missing term is expressed by the letter x. In the proportion 8 : 4 :: 160 : x, find the missing term. $\frac{4\times 160}{8}=x$; cancelling, $\frac{4\times \cancel{160}\ 20}{\cancel{8}}=80$; the missing term is 80.

In working with proportion certain rules must be remembered. Those rules are: 1. Let "x" always be the fourth term: 2. Let the third term be that number in the question which expresses the same kind of value as is expected in the answer; 3. Decide whether the answer sought will be greater or less than the third term, and if greater, the larger of the two remaining terms belongs in the second place, but if smaller, the lesser of the two remaining terms belongs in the second place; and 4. The remaining term goes in the first place.

To solve the problem of the solutions of different strengths by proportion, state the proportions as follows:

(*a*) $50 : 20 :: 500 : x; \frac{20\times 500}{50}=x$; cancelling, $\frac{20\times \cancel{500}\ 10}{\cancel{50}}=200; x=200.$

(*b*) $50 : 5 :: 500 : x; \frac{5\times 500}{50}=x$; cancelling, $\frac{5\times \cancel{500}\ 10}{\cancel{50}}=50; x=50.$

(*c*) $50 : 10 :: 500 : x; \frac{10\times 500}{50}=x$; cancelling, $\frac{10\times \cancel{500}\ 10}{\cancel{50}}=100; x=100.$

(*d*) $50 : 15 :: 500 : x; \frac{15\times 500}{50}=x$; cancelling, $\frac{15\times \cancel{500}\ 10}{\cancel{50}}=150; x=150.$

Therefore, to make 500 Gms. of a 20 per cent solution of silvol 200 Gms. of a 5 per cent solution, 50 Gms. of a 10 per cent solution, 100 Gms. of a 25 per cent solution, and 150 Gms. of a 40 per cent solution of silvol will be required.

PHARMACEUTICAL OPERATIONS AND PROCESSES

Heat.—From the time of the ancient Greeks different theories have been advanced to explain the nature of heat. The one now almost universally accepted is known as the dynamical theory of heat which assumes that heat is produced by the constant motion of the particles composing the body, and that heat varies in quantity dependent upon whether the body is solid, liquid, or gaseous. The kinetic theory of matter states that the molecules of all matter are in perpetual motion, striking against and rebounding from each other, and by that motion producing heat. It may therefore be said: Heat is that form of molecular motion, or molecular kinetic energy, which produces the sensation called warmth. More simply: Heat is a form of molecular motion.

The sun is the most important source of heat. Friction, electricity, light, and chemical action all produce heat and may be said to be sources of heat. Rubbing two pieces of wood together to kindle fires, and igniting substances from sparks obtained by striking a flint and steel together are examples of heat produced by friction; electricity passing through wires having high resistance to the passage of electricity, as in an electric toaster, is an example of producing heat by electricity; igniting a substance by concentrating the rays of the sun on it through a "burning glass" is an example of heat produced by light; the mixing of alcohol and water with the formation of hydrates of alcohol, and the burning of fuels are examples of the production of heat by chemical action.

Chemical action is an important source of heat and by chemical action is meant the breaking up of the molecules of a substance with the formation of new molecules. In chemical action, sometimes called decomposition, there is considerable movement of the molecules and their constituent atoms, which movement is a form of friction and therefore produces heat. The combining of iron with iodine in a test-tube in the presence of water, forming ferrous iodide, produces so much heat that the test-tube becomes so hot it can hardly be held in the hand. This is an example of heat produced by chemical action. The burning of wood is another example of heat produced by chemical action, but

the chemical action here is much different from that in the other example, because not only is the heat produced of greater intensity, but flame, or light, is also produced. This is due to the heat being so great and the reaction so rapid that some of the carbon in the wood fails to combine with oxygen and, becoming heated, glows as does the carbon filament in an incandescent light. Chemical action accompanied by heat and light is called combustion.

Any substance with which a combustion can be had is called a fuel. Fuels may be solid, as wood, charcoal, coal, coke, etc., liquid, as alcohol, kerosene, gasoline, petroleum, benzine, etc., or gaseous, as natural and artificial gas. In the burning of fuels it is necessary to have apparatus suitable for the fuel used.

Heat performs work according to the quantity of heat present. To measure the quantity of heat the unit used is the calorie. The calorie is the amount of heat required to raise the temperature of 1 Gm. of distilled water from zero to 1° C. This is known as the small calorie and there is also the large calorie which equals 1,000 small calories. The large calorie is generally used in expressing the energy or heat value of food substances.

There is a difference between heat and temperature which must be remembered. Heat is quantity or amount while temperature is quality, degree, or intensity. A gallon of water at 100° C. is just as hot as a barrel of water at 100° C. because the temperature is the same, but the quantity or amount of heat in the barrel of water is very much greater than that in the gallon of water. The intensity of heat is known as its temperature, the degree of intensity is determined by instruments called thermometers and is expressed relatively in degrees.

A *thermometer* is a glass tube with a capillary bore, sealed at one end and the other end terminating in a cylindrical or globular bulb which is usually filled with mercury. When subjected to the influence of heat the mercury expands and rises in the tube, the degree of heat being read either on a graduated scale marked on the tube or on a graduated scale placed at the side or back of the tube (fig. 146).

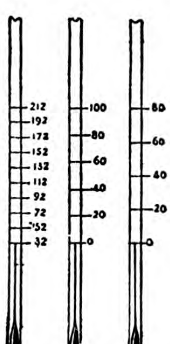


FIGURE 146.—Thermometers; from left to right, Fahrenheit, Centigrade, Reaumur. (Remington.)

The lower limit of accuracy of a mercury-filled thermometer is —30° C. because mercury freezes at —40° C.; the upper limit of accuracy of a mercury-filled thermometer is about 300° C. because mercury boils at 350° C. If that part of the capillary tube above the mercury column be filled with an inert gas, such as nitrogen, the mercury will be prevented from boiling by the pressure of the gas above it, and such a thermometer may be used for temperatures as high as 550° C.

The three scales used in marking thermometric degrees are Fahrenheit, Centigrade, and Réaumur. In the Fahrenheit scale the freezing point of water is 32, the boiling point is 212, and the intervening space is divided into 180 degrees. In the Centigrade scale the freezing point of water is zero, the boiling point is 100, and the intervening space is divided into 100 degrees. In the Réaumur scale the freezing point of water is zero, the boiling point is 80, and the intervening space is divided into 80 degrees. The Réaumur scale is rarely used in English-speaking countries. Most thermometers in use in the United States are graduated either in the Centigrade or the Fahrenheit scale, and some thermometers have both scales.

Statements of temperature are given in the U. S. Pharmacopœia in Centigrade degrees. The standard temperature for making specific gravity determinations,

solubility tests, polarimetric determinations, and for the preparation of volumetric solutions is 25° C. (U. S. P. XI.)

It is often necessary to convert the degrees of one scale into those of another, and in converting Centigrade degrees into Fahrenheit degrees or vice versa, it should be kept in mind that 100 degrees Centigrade are equal to 180 degrees Fahrenheit, or that 1° C. is equal to 1.8° F. It should also be kept in mind that on the Fahrenheit scale the freezing point of water is 32 degrees above zero or 32 degrees higher than on the Centigrade scale, and this difference of 32 degrees must be considered.

With temperatures above the freezing point of water, to convert Fahrenheit degrees to Centigrade degrees the rule is: *Subtract 32 from the number of Fahrenheit degrees and divide the remainder by 1.8. Problem.*—Convert 122° Fahrenheit to Centigrade; 122 minus 32 equals 90; 90 divided by 1.8 equals 50; the answer is 50° C.

With temperatures above the freezing point of water, to convert Centigrade degrees to Fahrenheit degrees the rule is: *Multiply the number of Centigrade degrees by 1.8 and to the product add 32. Problem.*—Convert 50° C. to Fahrenheit; 50 multiplied by 1.8 equals 90; 90 plus 32 equals 122; the answer is 122° F.

With temperatures below the freezing point of water, to convert Fahrenheit degrees to Centigrade degrees the rule is: *Add 32 to the number of degrees below the freezing point and divide the sum by 1.8. Problem.*—Convert —31° F. to Centigrade; 31 plus 32 equals 63; 63 divided by 1.8 equals 35; the answer is —35° C.

With temperatures below the freezing point of water, to convert Centigrade degrees to Fahrenheit degrees the rule is: *Multiply the number of degrees below the freezing point by 1.8 and from the product subtract 32. Problem.*—Convert —35° C. to Fahrenheit; 35 multiplied by 1.8 equals 63; 63 minus 32 equals 31; the answer is —31° F.

Heat is applied and temperature is controlled in pharmaceutical operations by the use of heat baths. Some of the commonly used heat baths are the water bath, salt-water bath, glycerin bath, oil bath, sand bath, etc. If it is desired to heat a substance at a temperature of 100° C., for some time, a water bath is used. It does not matter how much heat is applied to the water bath, the temperature will not go any higher than 100 degrees because this is the boiling point of water. The temperature of a liquid does not increase after it reaches the boiling point (unless confined), but the boiling points of different liquids vary greatly; the boiling point of water is 100° C., glycerin about 260° C., saturated solution of salt water about 108° C.; therefore, if it is desired to heat a substance no higher than 100° C., use a water bath; if a temperature of 106° C. is desired, use the salt water bath, etc. The sand bath is used for very high temperatures and must be cautiously used if a constant temperature is desired. Wire gauze is used under glass vessels when they are subjected to the direct heat of a flame to prevent them from breaking.

Pharmaceutical operations requiring the application of heat.

Not all pharmaceutical operations which require the application of heat are made use of in the retail drug store or the dispensary, most of them being employed only in manufacturing establishments and in laboratories when drugs are tested and analyzed.

In these operations the degree of heat used varies from what is called gentle heat to strong heat. In the definitions of these operations or processes which follow, the degree of heat used is named whenever it is essential to the process:

Ignition consists of strongly heating inorganic substances, with access of air, to obtain a definite residue.

Incineration is the process of strongly heating, or burning, organic substances in a crucible until nothing but ashes remain. This process is made use of in making analyses of certain organic substances.

Fusion is the process of liquefying solid substances by the application of heat without the use of a solvent. An example of this process is the melting of wax.

Calcination is the process of separating volatile substances, such as carbon dioxide, from fixed inorganic matter by the application of strong heat, without producing fusion. Magnesium oxide and calcium oxide (quick lime) are made by heating (calcining) the carbonates of magnesium or calcium which drives off the carbon dioxide and leaves behind the oxide. ($MgCO_3 + heat \rightarrow MgO + CO_2$),

Deflagration is the process of strongly heating one inorganic substance with another capable of yielding oxygen (usually a nitrate or a chlorate). Decomposition ensues, accompanied by a violent, noisy, or sudden combustion. Salts of antimony and arsenic may be made by this process.

Carbonization is the process of strongly heating organic substances without the access of air until they are charred. The volatile products are driven off and the non-volatile products, principally carbon, remain behind. Charcoal is made in this way.

Torrefaction is the process of moderately heating, or roasting, organic substances. The roasting of coffee is an example of the application of this process.

Vaporization is the process of separating volatile substances from fixed bodies or from less volatile bodies, usually with the aid of heat at varying temperatures. The use of this process has four principal applications as follows:

1. To separate a volatile liquid from a less volatile liquid, when it is called *evaporation.*
2. To separate a volatile liquid from a solid, when it is called *desiccation, exsiccation,* or *granulation.*
3. To obtain a volatile liquid, when it is called *distillation.*
4. To separate a volatile solid from a nonvolatile solid, when it is called *sublimation.*

Evaporation, as used in pharmacy, is the process of driving off the more volatile or less valuable portions of a liquid by the application of heat with the object either of purifying or concentrating the liquid for the purpose of obtaining the less volatile portion. An example of evaporation is the concentrating of liquids intended for crystallization. *Ebullition,* or *boiling,* is an important form of evaporation.

Desiccation is the process of depriving solid substances of moisture at as low a temperature as possible. The moisture driven out is known as *hygroscopic moisture* to distinguish it from the moisture combined in chemical salts as water of crystallization. This process is used to aid in the preservation, to reduce the bulk and weight, and to facilitate the comminution of medicinal substances.

Exsiccation is the process of depriving a solid crystalline substance of its water of crystallization or moisture by heating it strongly. The object of this process is to reduce the bulk and volume of substances. Exsiccated alum (burnt alum) is made by heating crystalline alum.

Granulation is the process of heating the solution of a chemical substance with constant stirring until nearly all of the liquid is evaporated and a coarse-grained powder is produced which usually is composed of very small

crystals. In granulation the solution is first evaporated rapidly, the heat then is moderated, and toward the end of the process the heat is very moderate.

Distillation is the process of heating liquids or solids until gas or vapor is driven off and condensing all or some of the gas or vapor back into the liquid which is sought. The first part of the process is identical with evaporation; the second part, called condensation, is the conversion of the vapor into a liquid by the application of cold. Distillation is extensively used in retail and in manufacturing pharmacy and there are three modifications known as fractional, destructive, and vacuum distillation. *Fractional distillation* is the process of separating mixed liquids having different boiling points. The liquids having low boiling points distill over first and in that way can be separated from those having high boiling points. *Destructive distillation* is the process of heating dry organic matter in a distillatory apparatus until the substance is decomposed and new products are formed, volatilized, and condensed. Oak wood subjected to this treatment breaks down into wood alcohol, acetic acid, acetone, creosote, and other products; coal, when subjected to this treatment yields illuminating gas, ammonia products, phenol bodies, cresols, benzene, toluol, dye color bases, and other products, while coke is left behind. *Vacuum distillation* is the process of facilitating evaporation by the removal of air pressure from the distilling chamber which permits the operation to be conducted at a lower temperature. The special advantages of vacuum distillation are made use of on a large scale by gasoline refineries, liquor distilleries, and factories manufacturing solvents.

Sublimation is the process of distilling solid volatile substances. The product is termed a sublimate. Many solid substances are purified from their impurities by this process, which is also made use of to obtain a solid substance in the form of a very fine powder. In sublimation the temperature at which the condensation of the vapor takes place largely determines the physical character of the sublimate. There are three kinds of sublimates: *Cake*, as camphor, corrosive sublimate, etc.; *Powder*, as calomel, sublimed sulfur, etc.; and *crystal*, as iodine, naphthalene, etc.

Pharmaceutical processes not requiring the use of heat.

Comminution is the process of reducing a substance to fine particles. Under this head are grouped various mechanical processes for accomplishing the necessary reduction, some of which are: Cutting, slicing, bruising, rasping, grating, chopping, rolling, stamping, grinding, trituration, levigation, elutriation, pulverizing, etc. The object of all these processes is to facilitate the solution of a substance or of its active principle and to permit of its administration in the form of a fine powder. Those most employed in retail dispensing are trituration, grinding, and pulverization. A few of them will now be described.

Trituration is the process of reducing substances to fine particles in a mortar with a pestle. Mortars are usually made of glass, porcelain, or wedgewood and the pestles are made of the same material as the mortar. The substance to be triturated is placed in the mortar and rubbed with the pestle. The motion of the pestle should follow the curve of a spiral, beginning in the center and gradually working outward. This process is employed more than any other in a retail dispensary when it is desired to reduce a substance to fine particles.

Levigation is the process of reducing substances to a state of minute division by triturating them after they have been made into a paste with water or other liquid. A shallow mortar with a properly fitting pestle, or a ground-glass slab with a flat-surfaced glass muller is required. When the slab and the muller

are made of porphyry the process is called *porphyrization.* The motion given to the muller should closely follow the lines of the figure 8 or of oval loops intersecting each other, the object being to so vary the motion that all particles of the powder are reached.

Elutriation is the process of separating coarser from finer particles of insoluble substances by suspension in water, and is sometimes called *water-sifting.* The substance is powdered, mixed into a thin paste with water, and thrown into a vessel containing water. After allowing the heavier particles to subside, the liquid containing the lighter particles is decanted into another vessel, and the fine particles allowed to settle. Later the clear liquid is drawn off. Prepared chalk is an example of a substance obtained by elutriation.

Pulverization by intervention is the process of reducing substances to powder through the use of a foreign substance from which the powder is subsequently freed by some simple method, such as evaporation. Camphor can be reduced to a fine powder by triturating it in the presence of a few drops of alcohol or chloroform.

After a drug has been reduced to a fine state of subdivision it is often necessary to separate the fine from the coarse particles which is accomplished by *sifting* with a sieve. Sieves are numbered 20, 40, 60, 80, and 100, according to the number of meshes per linear inch of the screen. The degree of fineness of a powder is designated by the number of the finest sieve through which it will pass. A number 80 powder is one that will pass through a number 80 sieve but will not pass through a number 100 sieve. The degree of fineness is also designated by the terms coarse powder (20), moderately coarse powder (40), moderately fine powder (50), fine powder (60), very fine powder (80), etc.

The reduction of vegetable drugs to fine particles is necessary to allow the extraction of their soluble principles in making tinctures and fluidextracts. A glance at the U. S. Pharmacopœial formulas for making tinctures and fluidextracts will show that the fineness of the powder to be used is always specified. In some cases a coarse powder, sometimes a moderately fine, and again a very fine powder is specified. A vegetable drug having fine cells must be reduced to fine particles in order to break up as many of the cells as possible because the active principles of the drug might be confined within a tough cell wall, and if this wall remained unbroken the active principle might escape extraction.

Solution.

A solid, liquid, or gaseous substance can be so completely absorbed into, and so homogeneously mixed with, another liquid substance, that it can be said to have disappeared in that liquid substance. This is because the particles of the first substance are so uniformly diffused through the liquid that they do not separate upon standing, cannot be detected even under a high power microscope, and cannot be removed by filtration.

When substances are thus combined the result is what is called a true or simple *solution,* which may be defined as *a permanent and complete molecular incorporation of a solid, liquid, or gaseous substance in a liquid substance.* The substance incorporated in the liquid is called the *solute,* and the liquid in which the substance is incorporated is called the *solvent.*

Solutions may be divided into several different classes according to the different ways in which solution is effected or according to the physical states of the components, but in pharmacy the principle concern is with solutions of solids, liquids, and gases in liquids. Two of these classes are *simple,* in which no change occurs in the chemical structure or identity of the dissolved substance, as when sugar is dissolved in water, and *chemical,* in which there is a

change in the chemical structure or identity of the dissolved substance, as in the making of solution of nitrate of mercury, when red mercuric oxide is dissolved in a mixture of nitric acid and distilled water and the mercuric oxide changes to mercuric nitrate. In simple solutions the process of evaporation will recover the dissolved substance with its identity unchanged, but evaporation of chemical solutions will not yield the original dissolved substance for its identity has been changed.

A *saturated solution* is a solution in which, at a given temperature, the solvent has taken up the maximum amount of the solute. In other words, the solvent can dissolve no more of the solute. A saturated solution is usually understood to be made at 25° C., the standard temperature for solubilities prescribed by the U. S. Pharmacopœia. Practically, saturated solutions are made up at ordinary room temperature. A solution might be saturated with one substance and still be capable of dissolving a large amount of another substance. When a saturated solution is cooled below the temperature at which it is made, precipitation usually occurs; therefore, a saturated solution made during the summer would undergo a certain amount of precipitation if kept until winter.

A *supersaturated solution* is one that contains more of a given substance than it will retain at ordinary temperature. A supersaturated solution is made by heating the solvent and dissolving the substance in it while hot. When such a solution cools precipitation of the excess takes place.

Solution is aided by agitation, heat, comminution, and by slightly changing the chemical character of the substance to be dissolved. Heat aids solution by keeping the liquid in motion, and by increasing the size of the intermolecular spaces of both the solvent and the solute, allowing an intermingling of the molecules. (*See* under molecular physics in chapter on Chemistry). The increase in the size of the intermolecular spaces accounts for expansion of a substance when it is heated, and for the fact that a hot solvent will dissolve more of a given substance than a cold solvent.

Chemical action aids solution by changing the chemical composition of the substance to be dissolved. Quinine sulfate which is normally soluable in 720 parts of water can be made to dissolve in 9 parts of water by addition of a few drops of hydrochloric acid. Iodine which is practically insoluble in water can be made to dissolve freely by the addition of potassium iodide. In these cases the chemical character of the substances is very slightly changed. In other cases chemical action aids solution by producing a complete and permanent change in the character of the substance dissolved.

The solubility of a substance is indicated in the U. S. Pharmacopœia by stating the minimum number of cc of solvent that 1 Gm. of the substance will dissolve in at 25° C. It is also expressed in some cases by the use of such terms as freely soluble, sparingly soluble, soluble, very soluble, etc.

Some of the more common solvents used in pharmacy are water, alcohol, diluted alcohol, glycerin, petroleum benzine, liquid petrolatum, benzene, ether, chloroform, diluted acetic acid, fixed oils, volatile oils, and diluted ammonia water.

Water dissolves many compounds both organic and inorganic, inorganic salts, alkaloidal salts, gums, etc. It is chemically and therapeutically inactive, and in general has no effect on the substances dissolved in it. One of the objections to its use is the tendency for microscopic plants of the fungus type to grow in it; this is overcome largely by the use of recently boiled distilled water. It is very often mixed with other solvents in the manufacture of

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official preparations. It is the solvent used in the preparation of the official waters and liquors. Water has no preservative properties, which is one of its principal disadvantages.

Alcohol is, next to water, the most important solvent used in pharmacy. It is frequently used as a solvent mixed with different proportions of water in the preparation of tinctures and fluidextracts. It dissolves many substances that water will not and it possesses preservative properties that give it a decided advantage over water. The principal objection to its use is that even in small quantities it produces its characteristic effect on the system. It dissolves resinous drugs, oils, many organic and inorganic compounds, alkaloids, and many other substances. It is used in making tinctures and fluidextracts.

Glycerin will dissolve many substances that water will, and will precipitate but few substances from aqueous solution. It mixes well with alcohol or water and is often used with one or both of these solvents. It is an excellent solvent for tannin and phenol. It is used as the solvent in the preparation of the U. S. P. glycerites.

Separation of fluids from solids.

Some of the processes for separating fluids from solids are *lotion, decantation, colation, filtration, clarification, expression, percolation,* etc.

Lotion (meaning to wash) is the process of separating soluble matter from a solid by pouring upon the solid a liquid which will dissolve and wash out the soluble portion. This process is usually preceded by filtration or straining, and the substance to be washed is usually what remains on the filter after the excess liquid has drained off. Lotion is made use of extensively in making chemical analyses of substances.

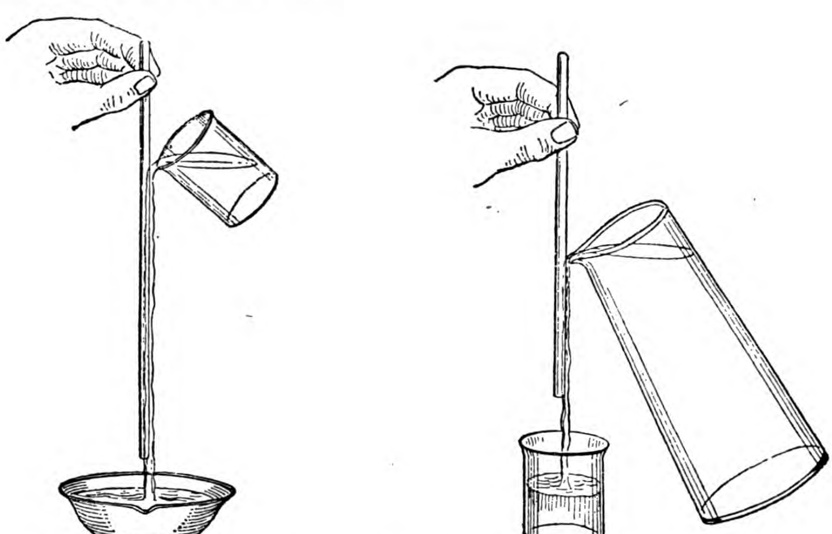

FIGURE 147.—Decantation from beaker (left) and from precipitating jar (right). (Arny.)

Decantation is the process of separating a liquid from a solid by pouring off the liquid after the solid has settled. This is sometimes better effected by use of a syphon. Decantation is a very effective method of washing soluble substances from solids. (Fig. 147.)

Colation (straining) is the process of separating a solid from a liquid by pouring the liquid mixture upon a cloth strainer stretched on a frame. The

cloth usually is a piece of gauze, muslin, or flannel, depending on the character of the liquid that has to pass through it. This process is employed in straining those liquids that will not pass readily through a filter paper.

Filtration is the process of separating liquids from solids with the view of obtaining the liquid in a transparent condition and free from the very finest particles of insoluble matter. Of all the processes made use of in separating solids from liquids filtration is the most important. Filters are made of paper, paper pulp, sand, asbestos, ground glass, charcoal, porous stone, glass wool, etc.

Clarification is the process of separating from liquids, without the use of strainers or filters, solid substances which interfere with their transparency. This process is seldom used in pharmacy. It is sometimes substituted for filtration or straining in the case of liquids that will not pass through a strainer, or where straining is slow or difficult. Clarification may be effected by the application of heat, by the addition of water, by the use of albumin, gelatin, or milk, by fermentation, by the use of paper pulp, and by long standing, when the solid substance settles to the bottom of the container and is known as a *sediment*. This method of clarification is sometimes called sedimentation.

Precipitation is the process of separating a solid from its solution by the action of heat, light, or chemical substances. The separated solid is termed a *precipitate;* the cause of the precipitation the *precipitant;* and the liquid which remains in the container the *supernatant liquid.* A precipitate may either rise to the top or sink to the bottom of the liquid from which it is precipitated, according to whether it is heavier or lighter than the liquid. Whereas a sediment is solid matter separated from solution by gravity, being merely suspended instead of dissolved in the solution, a precipitate is solid matter that has been separated from solution.

The objects of precipitation are to obtain solid substances in the form of fine powder, to purify substances, and to identify a substance in chemical testing. The physical characteristics of precipitates are described by the words curdy, granular, bulky, flocculent, gelatinous, crystalline, etc. A *magma* is a thick tenacious precipitate left after the liquid is decanted. The character of precipitates, whether heavy or light, may be controlled by regulating the concentration and temperature of the two solutions which are poured together to produce the precipitate. Light precipitates are made by mixing cold diluted solutions, and heavy precipitates are made by mixing hot concentrated solutions.

Crystallization is the process by which substances are caused to assume certain definite geometric forms called crystals having plane surfaces called faces, edges and angles. The scientific classification of crystals is based on the length, number, and relative position of their axes (plural of the word axis) and in this classification six systems are commonly recognized. In describing crystals the Pharmacopœia does not always use scientific terms but general terms such as prismatic, laminar, acicular, cubical, etc.

Substances that crystallize are known as crystalline and those that do not as amorphous substances. When a substance crystallizes in two or more forms belonging to different systems it is said to be dimorphous, trimorphous, polymorphous, etc. When different substances crystallize in the same form they are said to be isomorphous. Crystallizable substances always assume their own characteristic form, or some form directly derived from it or related to it.

The principal object of crystallization is to obtain a substance in a highly purified form. Crystals are obtained by the following different methods: Fusion and partial cooling; sublimation; deposition from supersaturated solutions as they cool; deposition from solutions during evaporation; deposition

from solutions while a galvanic current is passing through them; precipitation; adding a substance having a strong affinity for water. In pharmacy the use of granular crystals is usually preferred for the reason that they are more readily soluble than are large, perfect crystals.

Many substances in the act of crystallizing combine chemically with water, and this water is known as *water of crystallization*. The amount of water of crystallization that a substance contains is expressed relatively by stating the number of molecules of water (H_2O) that are loosely combined with one molecule of the substance. The formula for monohydrated sodium carbonate is $Na_2CO_3.H_2O$, which means that each molecule of Na_2CO_3 contains one molecule of H_2O; the formula for magnesium sulfate is $MgSO_4.7H_2O$, which means that each molecule of $MgSO_4$ contains seven molecules of H_2O.

When crystalline substances are heated the water of crystallization is driven off and they are then known as exsiccated or anhydrous substances. If an exsiccated salt is dissolved in water and the solution evaporated gently the exsiccated salt will recrystallize with the same amount of water of crystallization that it originally contained.

In determining the molecular weight of a substance, the molecular weight of the water of crystallization is added to the molecular weight of the substance without water.

When crystals lose their water of crystallization and form a powder on the outside they *effloresce;* crystals that absorb water are said to be *hygroscopic*, and when they absorb sufficient water to liquefy they are said to *deliquesce*. The liquid remaining after crystals have formed is known as the *mother liquor*.

Some substances in crystallizing form masses of crystals and in the process mechanically imprison water in the interstices between the crystals. Such imprisoned water is called *interstitial water* to differentiate it from water of crystallization, and crystals may be freed of it by crushing the mass or gently heating it.

It is sometimes necessary to separate crystallizable from noncrystallizable substances and the process of separating them is known as *dialysis*. The vessel used for this operation is called a *dialyzer* and has a drum-like head or diaphragm made of parchment-like membrane at one end. Into this the substances to be separated are placed in the form of a solution and whole is floated on water where the crystallizable substance passes through the drum head into the water below, leaving the noncrystallizable substance behind. In this operation the crystallizable substances are called *crystalloids* and those which are not crystallizable are called *colloids*. The object of dialysis is to obtain either the crystallizable or noncrystallizable substance free from the other.

Extraction is the process of separating soluble principles from drugs by treating them with a liquid in which the principles are soluble. There are five principal methods of extraction: *Maceration and expression, digestion, percolation, infusion,* and *decoction*. The solvent used in all cases of extraction is called the *menstruum*.

Maceration is the soaking of a drug in the appropriate menstruum at room temperature until the soluble portion of the drug is dissolved. After the drug has soaked for some time, with frequent shaking, the insoluble matter is separated by straining and expression. **Expression** is the forcible separation of liquids from solids and is accomplished usually by the use of presses which in pharmacy are known as spiral twist, screw, roller, wedge, lever, and hydraulic, according to the mechanical principles involved in their action. This process is preferred to percolation in making strong extracts of vegetable drugs where a long time is required for the liquid to permeate the dried particles, and in

the case of those drugs which clog a percolator. Maceration is sometimes aided by suspending the ground drug, tied in a bag, in the upper part of the menstruum. This is known as *circulatory maceration.* When gentle heat is applied during the process of maceration or when warm water is used the process is then called *digestion.* **Infusion** is the process of extracting the water soluble principles from vegetable drugs by pouring hot water on the drug or by treating the drug with cold water for a definite length of time. Cold water should be used when the drug contains a valuable volatile principle, when the active principle is injured by heat, and when the desired principles are readily soluble in water of ordinary temperature. If the mixture of drug and water is boiled to secure the active principles of the drug the process is then called **decoction.** The last of the methods of extraction is that now to be discussed.

Percolation is the process whereby a powder contained in a suitable vessel is deprived of its soluble constituents by the descent of a solvent through it. This process is also known as displacement. The U. S. Pharmacopœia directs that a substance, in powder, contained in a vessel called a *percolator,* be subjected to the solvent action of successive portions of menstruum in such manner that the liquid, as it traverses the powder in its descent to the receiver, shall be charged with the soluble portions and pass from the percolator free from insoluble matter.

A percolator is a cylindrical or conical vessel with a porous diaphragm at the bottom, into which the drug in the form of a powder is introduced, and its soluble portions extracted by the descent of the solvent through it. (Fig. 148).

The solvent, or menstruum, which is poured on the top of the powder, in passing downward exercises its solvent power on the successive layers of the powder until saturated, and is impelled downward by the combined force of its own gravity and that of the column of liquid above, minus the capillary force with which the powder tends to retain it. When the menstruum, saturated with the soluble principles of the drug, escapes from the bottom of the percolator it is known as the *percolate.*

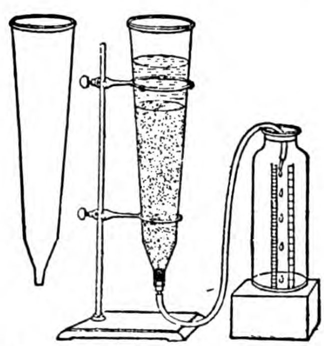

FIGURE 148.—Official percolator (left) and process of percolation (right). (Remington.)

It has been stated before that vegetable drugs must be reduced to fine particles in order to break up the walls of the cells within which much of the active principles of the drug is contained. After grinding or otherwise breaking up the vegetable drug the soluble principles are to be found in the fine dust scattered through the powdered drug and in the thoroughly disintegrated particles. In this form but little resistance is offered to the passage of the solvent through the powder and the first portion of the solvent passing through the powder will come in contact with more of the soluble principles than will the later portions. The solvent first takes up the soluble principles released through grinding and powdering and afterward permeates the cells and cell walls to take up any soluble principles remaining in them. Consequently, the percolate first escaping from the percolator is more highly colored and contains more of the soluble principles than the later portions.

The process of percolation may be divided into six steps as follows: 1. Comminution or reduction of the drug to the required degree of fineness; 2. Moistening of the drug; 3. Maceration or soaking of the drug either within or without the percolator before pouring on the menstruum; 4. Packing the

drug in the percolator; 5. Pouring on the menstruum; 6. Regulating the flow of and collecting the percolate.

The process of percolation is used in pharmacy in the preparation of tinctures, fluidextracts, etc., and it has a great advantage over maceration in extracting the soluble principles of drugs as by percolation every trace of soluble matter can be removed.

PHARMACEUTICAL PREPARATIONS OFFICIAL IN THE U. S. PHARMACOPŒIA XI

In this section only those pharmaceutical preparations named in the U. S. Pharmacopœia XI will be discussed as they are those commonly known as "official", or "pharmacopœial", preparations, the U. S. P. XI directing that the word "official" shall "be considered as synonymous with 'pharmacopœial' ". In addition to the "official" pharmaceutical preparations herein discussed there are others recognized by the National Formulary and miscellaneous ones not recognized by the U. S. Pharmacopœia or the National Formulary which are frequently used in the practice of pharmacy.

Pharmaceutical preparations manufactured by the processes which have been described in the preceding section are divided into two main classes known as *galenical preparations* and *chemical preparations.* Galenical preparations are those in the manufacture of which no chemical action is involved; they are simple solutions or mechanical mixtures. Chemical preparations are those in which chemical changes occur during the process of their manufacture.

They are also grouped further in two general classes of liquids and solids according to the nature of the preparation. Liquid preparations are those in which the medicinal substance is contained in various liquid vehicles, and solid preparations are those in which the medicinal substance is incorporated in a solid or semisolid vehicle. Liquid and solid preparations may also be grouped in classes according to the nature of the principal vehicle used in their manufacture, as aqueous, oleaginous, etc., and according to the nature of the preparation, as extracts, pills, etc. Both liquid and solid preparations may be made with maceration and percolation or without maceration and percolation.

In addition to these pharmaceutical prepartions there are *natural preparations* used in pharmacy, some of which are alkaloids, glucosides, and other neutral principles, acids, alkalies, etc.

Liquid preparations.

Aceta (vinegars) are solutions of the active principles of vegetable drugs in diluted acetic acid. Diluted acetic acid is used as a menstruum because it is a good solvent and also possesses antiseptic properties. Vinegars are a very old class of pharmaceutical preparations but are gradually passing into disuse. There is but one official vinegar in the U. S. P. XI, *Acetum scillæ;* vinegar of squill.

Aquæ (waters) are aqueous solutions of volatile substances, and are also known as medicated, aromatic, or distilled waters. In the U. S. P. XI are listed *Aqua destillata,* distilled water, and *Aqua destillata sterilisata,* sterilized distilled water, neither of which contain anything in solution.

The substances used in the preparation of waters may be either solid, liquid, or gaseous, but they are all volatile. Many of the waters are made from volatile oils which are only slightly soluble in water and such waters are spoken of as aromatic waters. They have very little medicinal effect and are used principally as flavored vehicles in which active drugs are administered. Ammonia

water differs from the other waters in that it is a powerful caustic and must be handled with care.

Four methods are employed in the preparation of waters as they are made from substances that are not readily soluble in water. The methods are: 1. Simple solution in cold water; 2. Filtration with the aid of an absorbent powder; 3. Filtration with the aid of pulped or shredded filter paper; 4. Distillation. For making waters by the process of filtration through an absorbent powder the Pharmacopœia recommends the use of purified talc.

In the preparation of most of the waters official in the Pharmacopœia it is directed that distilled water be used, and the use of distilled water that has been recently boiled is preferable as it is then free from the microörganisms that produce unsightly growths in waters after they have stood for some time.

The term "aromatic waters" refers to those waters made from odorous principles and which are used chiefly as perfumes and flavorings. After aromatic waters stand for a long time they deteriorate and are unfit for use; therefore they should be made up only in small quantities as required.

Fifteen waters are recognized in the U. S. P. XI.

Collodia (collodions) are liquid preparations intended for external use having as their base a solution of pyroxylin, or gun-cotton, in a mixture of ether and alcohol. When applied to the skin the ether and alcohol evaporate and leave a thin film of gun-cotton ("new skin") which acts as a protective. The layer of gun-cotton left after evaporation of the ether and alcohol is brittle and liable to crack when applied to a movable joint. In flexible collodion a small amount of castor oil is added with the result that the film left after evaporation is pliable. Two collodions are official.

Decocta (decoctions) are liquid preparations made by boiling vegetable drugs with water for 15 minutes. There are no official decoctions but a general formula for their preparation is provided in the Pharmacopœia. This formula directs that 50 Gms. of drug, coarsely comminuted, be boiled with sufficient water to make 1,000 cc of decoction. Decoctions spoil quickly and should never be dispensed unless freshly made.

Elixiria (elixirs) are aromatic, sweetened, hydro-alcoholic solutions sometimes containing active medicinal substances. Aromatic elixir, composed of water, alcohol, and syrup, flavored with compound spirit of orange, is used as the vehicle in preparing most medicated elixirs. Two elixirs are official.

Emulsa (emulsions) are liquid preparations in which oily or resinous substances are suspended in water by means of adhesive, mucilaginous, or other viscid matter. They are sometimes classified as *natural* and *prepared* emulsions. A natural emulsion is one which exists ready formed in Nature, of which typical examples are milk, egg yolk, and rubber latex; a prepared emulsion is one which is made artificially, of which all pharmaceutical emulsions are examples.

Oil and water are two liquids of which emulsions may be formed, and according to whether the oil is mixed in the water or the water in the oil, emulsions are known as the *oil-in-water type* (cod-liver oil emulsion) or the *water-in-oil type* (Carron oil).

Violently shaking oil and water together produces an emulsion for the moment but on standing the oil and water quickly separate because there is nothing present to keep the fine globules of oil from running together and separating from the water. In order to make an emulsion that is stable and will not separate it is therefore necessary to use a third substance known as an *emulsifier* or *emulsifying agent* which is a substance that makes it possible

for one liquid to hold another liquid in suspension without "breaking" or "cracking", terms used when the particles in an emulsion separate and run together. Most substances which produce foam in water are good emulsifying agents. They may be saponaceous (soapy), mucilaginous (gummy), or albuminous (white of egg) in character. The most commonly used emulsifying agents are acacia, tragacanth, egg yolk, Irish moss, casein, etc. Casein is obtained from milk, a natural emulsion.

Prepared emulsions usually are made by either the *Continental* or the *English* method. The Continental method, sometimes called the 4–2–1 method because 4 parts of oil, 2 parts of water, and 1 part of emulsifying agent are first mixed to make the nucleus or primary emulsion, produces an emulsion quicker than the English method and is more generally used, as a good emulsion always results if the method is correctly followed.

In making an emulsion by the Continental method the first step is to place the oily or resinous substance in a dry mortar, add the emulsifying agent, and rapidly triturate them until intimately mixed. The next step is to add the water *all at once* and continue to triturate rapidly and vigorously until a thick, creamy emulsion results, which is the nucleus or primary emulsion. The final step is to bring the emulsion up to its final volume and the proper strength by adding water to the nucleus in small portions with constant trituration.

Triturating the oily or resinous substance reduces it to a state of very fine subdivision, or in other words breaks it up into very fine particles which are intimately mixed with the emulsifying agent. When the first water is added a mucilage is formed with the emulsifying agent and each fine particle is surrounded or enveloped by a thin film of the mucilage which holds them in suspension and prevents them from running together again. Four emulsions are official.

Fluidextracta (fluidextracts) are liquid preparations of vegetable drugs containing alcohol as a solvent or as a preservative, or both, and so made that each 1 cc contains the therapeutic constituents of 1 Gm. of the standard drug which it represents.

Fluidextracts resemble tinctures but they are stronger. The solvents used and the methods employed in their preparation are much like those for the preparation of tinctures. Some of the advantages possessed by fluidextracts are permanence, concentration, and uniform relation between the drug and the fluidextract. They keep well because they are made with a menstruum containing alcohol, and sometimes glycerin, both of which are preservatives. The concentration of the active principles of a vegetable drug in a small volume of liquid reduces the volume of the dose and thereby largely avoids the physiological effect of the alcoholic menstruum which is one of the objections to the use of tinctures, especially weak tinctures that are given in large doses. The uniform relation (1 Gm. of the standard drug equaling 1 cc of the fluidextract) existing between the vegetable drug and finished fluidextract simplifies calculations in the preparation of doses.

The official fluidextracts are standardized whenever made from a drug that is capable of being assayed either chemically or biologically. They are made by the process of percolation and the menstruum to be used is specified in each case, the rate of flow of the percolate is directed, and the time of maceration is prescribed, so that the medicinally active or important constituents may be completely extracted from the specified quantities of the drug. The Pharmacopœia provides four general formulas or processes for making fluidextracts which are known as Processes A, B, C, and D. Process A is used for preparing

fluidextracts with menstrua of alcohol or with mixtures of alcohol and water by ordinary percolation; Process B is used in preparing fluidextracts, the menstrua for which contain, in addition to alcohol, or a mixture of alcohol and distilled water, definite quantities of other components such as an acid or glycerin, the two menstrua being successively employed; Process C, known as fractional or divided percolation, is used for preparing fluidextracts of drugs whose constituents are injured by heat; and Process D is used for preparing fluidextracts with boiling distilled water as the menstruum, alcohol being added to the concentrated percolate as a preservative. Eleven fluidextracts are official.

Glycerita (glycerites) are mixtures or solutions of medicinal substances with glycerin. They can easily be diluted with water without causing precipitation of the substance dissolved in the glycerin. Many substances can be dissolved in greater concentration in water if they are first dissolved in glycerin and the glycerin solution then mixed with water. For example, if it is desired to make a solution of phenol in water of a greater strength than 5 per cent it can be done by making a 50 per cent solution of phenol in glycerin and then diluting that solution to the desired percentage strength. Three glycerites are official, one of which, glycerite of starch, is a semisolid.

Infusa (infusions) are liquid preparations made by treating vegetable substances with either hot or cold water. They are seldom used in America and as they spoil quickly should be used the same day they are made or as soon as possible. There are no official infusions but the Pharmacopœia provides a general formula for their preparation. In making infusions boiling water may be poured over the drug but it should not be subjected to the boiling process. They usually are made by maceration, digestion, percolation, or by diluting concentrated preparations.

Linimenta (liniments) are solutions or mixtures of various substances in oily or alcoholic liquids intended for external use by friction and rubbing of the skin. In dispensing liniments the container should always bear a label indicating that they are for external use only. Four liniments are official.

Liquores (solutions) are aqueous solutions of nonvolatile substances. This group of pharmaceutical preparations usually contains very active medicinal substances and some solutions contain powerful poisons. Generally they are classed as *simple* or *chemical* solutions, according to the methods by which they are prepared. Those classed as simple solutions are made by the ordinary process of dissolving the drug in water and without any change in the chemical structure of the dissolved substance; chemical solutions are those in the making of which the chemical structure or identity of the dissolved substance is changed because of chemical reaction at the time solution is effected and the original identity is lost. Twenty-one solutions are official.

Magmæ (magmas) are aqueous suspensions of the finely subdivided insoluble constituents of inorganic substances. They are closely related to mixtures and consist of soft, thick, tenacious precipitates suspended in water. Two magmas are official, one of which, Magma ferri hydroxidi, is used only as an antidote for arsenic poisoning. It is sometimes known as "the official antidote" for arsenic poisoning and should never be used unless freshly prepared.

Mistura (mixtures) are aqueous liquid preparations intended for internal use containing insoluble nonfatty substances. Frequently the insoluble matter is suspended by the aid of viscid or sweet liquids but generally it is in the form of a sediment in the bottom of the container.

The insoluble matter usually constitutes the principal part of a mixture and it is therefore important that mixtures be dispensed with a "Shake Well"

label. Mixtures do not keep well because they usually contain substances that are prone to fermentation. They differ from emulsions in containing no fat and from liniments in being used internally. There are two official mixtures.

Mucilagines (mucilages) are thick aqueous preparations containing viscid substances in solution or suspension. They are made by dissolving gum in water, or by extracting with water the mucilaginous principles of vegetable substances. Mucilages readily undergo fermentation on standing and therefore should always be made fresh when needed; they are used as emollients, as emulsifying agents in making emulsions of oily substances, as pill excipients, and as suspending agents in mixtures. Two mucilages are official and one is made with heat, the other without heat.

Oleata (oleates) are solutions of metallic oxides or alkaloids in oleic acid. They are used externally by rubbing them on the skin, through which the active medicinal agent they contain is absorbed and produces its constitutional or local effect. Oleic acid is more readily absorbed than most of the fatty substances used in making ointments. One oleate is official.

Oleoresinæ (oleoresins) are liquid preparations consisting principally of natural oils and resins extracted from vegetable substances by percolation with acetone, ether, or alcohol. Subsequent distillation and evaporation of the solvent leaves behind the oleoresin. They are the strongest liquid preparations of vegetable drugs produced and can be prepared only from drugs containing volatile oil and resin. Besides the *pharmaceutical oleoresins* there are *natural oleoresins*, which are mixtures of volatile oil and resin exuding from plants. Examples of natural oleoresins are turpentine and copaiba. There is but one oleoresin official in the U. S. P. XI.

Spiritus (spirits) are alcoholic solutions of volatile substances. They differ from waters only in the solvent used (alcohol instead of water) and a number of volatile substances used in making medicated waters are also used in making spirits. Volatile oils are more soluble in alcohol than in water and the amount of volatile oil in a spirit is therefore much greater than in a water. The average strength of spirits is from 5 to 10 per cent although some are less than 5 per cent and some more than 10 per cent in strength.

They are made by: 1. Simple solution; 2. Solution with maceration; 3. Chemical reaction; and 4. Distillation. The spirits made by dissolving volatile oils in alcohol are popularly called "essences", as Essence of Peppermint. There are thirteen official spirits.

Syrupus (syrup) is a concentrated solution of sucrose in water or aqueous liquids. When distilled water alone is used in making the solution of sucrose the result is known as *simple syrup;* when the solution contains soluble medicinal principles the syrup is known as a *medicated syrup;* and if the solution contains aromatic or pleasantly flavored substances not medicinal in nature the syrup is called a *flavored syrup.*

In the preparation of syrups a high grade of sucrose (sugar) should be used, preferably a grade that meets the requirements of the Pharmacopœia. Syrup made from inferior grades of sucrose (sugar) is usually colored, does not keep well, and contains impurities. In preserving syrups they should be kept in a cool place in well-filled bottles. A fresh supply of syrup should never be placed in a bottle containing even a trace of old syrup. The bottle should be washed with hot water before refilling. In preparing simple syrup it should be made concentrated because a saturated syrup keeps better than a diluted one. Fourteen syrups are official.

Tinctura (tinctures) are alcoholic or hydro-alcoholic solutions of the active principles of animal or vegetable drugs according to the definition given in

the U. S. P. XI. They are also defined as alcoholic solutions of nonvolatile substances. Tinctures are different from spirits as they are made from non-volatile substances, but the tinctures which contain volatile substances extracted from drugs and those which contain iodine are exceptions to the general definitions. Iodine is a volatile, nonmetallic substance or element.

Tinctures constitute one of the most important classes of pharmaceutical preparations. Their strength varies, that of the potent, or strong, tinctures being commonly spoken of as 10 per cent, which means that they contain in 100 cc of finished tincture the active principles of 10 Gms. of the standard drug, while others are stronger or weaker than 10 per cent. The U. S. P. requires that a number of tinctures be assayed in order that the strength may conform to the standard adopted.

Two general processes for the making of tinctures are prescribed in the U. S. P. XI. They are Process P, or percolation, and Process M, or maceration. The menstrua used are alcohol, diluted alcohol of various strengths, aromatic spirit of ammonia, ether, ammonia water, or mixtures of alcohol, water, and glycerin. Tincture of iodine is made by the process of solution, the iodine being dissolved in a solution of potassium iodide and alcohol added; tincture of ferric chloride is made by diluting the solution of ferric chloride with alcohol.

Tinctures should be kept in a cool place, in tightly stoppered containers, and protected from light. Thirty are official.

Solid preparations.

Cerata (cerates) are combinations of medicinal substances with fats and waxes intended for external application. They are stiff, ointment-like preparations of such consistence that at ordinary temperatures they may be easily spread on cloth or paper, but not soft enough to liquefy and run when applied to the skin.

They are called cerates because they contain wax (*cera*) and are generally made with oil, lard, or petrolatum for a basis, with sufficient wax, paraffin, or spermaceti sometimes being added to raise the melting points of oils and fats. They are made either by fusion or by incorporation and three are official.

Emplastra (plasters) are solid preparations intended for external application and containing medicinal substances. Plasters should be of such consistence that they are pliable and will adhere to the skin. Some require the aid of heat in their application.

The plaster base or mass which contains the medicinal substance generally is made of lead plaster (a compound of litharge and oil), gum-resins, resin plaster (a compound of resin, lead plaster, and wax), Burgundy pitch, isinglass, and India rubber, or combinations of these substances. The plaster mass is spread upon a backing of muslin, paper, cotton cloth, etc., of suitable size and shape.

Common adhesive plaster contains no medicinal substance and is a mixture of rubber, resins, and waxes with one or more fillers of an absorbent powder as zinc oxide, orris root, starch, etc.

Most plasters today are machine made and their manufacture is seldom called for in the practice of pharmacy. Four are official.

Extracta (extracts) are solid or semisolid preparations containing the soluble and active principles of vegetable and animal drugs. They are obtained by extracting the soluble and active principles of those drugs with appropriate menstrua and evaporating the percolates to the proper consistency. According to their consistency extracts are divided into two classes: Soft, plastic masses,

known as *pilular extracts*, and dry powders, known as *powdered extracts*. The menstrua employed in making extracts vary, alcohol, distilled water, alcohol with distilled water, alcohol with ammonia, alcohol with an acid, and alcohol with glycerin all being used.

Extracts contain the active constituents of drugs in a concentrated, uniform, and permanent condition. Those made from alkaloidal drugs are required by the Pharmacopœia to be standardized as to strength and assay processes are prescribed for this purpose. After the menstruum has been evaporated off a portion of the extract is assayed and the remainder, as determined from the strength shown by the assay, is adjusted to standard strength. In the cases of those extracts not required to be assayed the finished extract is adjusted so that its weight bears a uniform relation to the amount of the drug that was percolated in making the extract. In the finished extract of cascara sagrada 1 gram must be equal to 3 grams of the powdered cascara bark used in the manufacture, because the U. S. P. directs that 900 Gms. of cascara sagrada bark, in fine powder, be exhausted by percolation, the percolate evaporated to dryness, reduced to fine powder, weighed, and enough diluent added to make 300 Gms. of finished extract. The diluent is the substance used to adjust the finished extract as necessary to meet the requirements of the Pharmacopœia. Glucose is directed as the diluent for pilular extracts and starch for powdered extracts but the use of others is permitted.

Pillular extracts are soft solids intended for use in making ointments, pills, suppositories, etc. In their preparation the U. S. P. directs that they be diluted, when necessary, with glucose in order to reduce them to the standard strength. Soft extracts should be kept in a cool place, away from light, and in well closed containers to prevent evaporation. If the containers are left open they become hard and dry. Extracts vary slightly in their strength from time to time due to loss of moisture.

Powdered extracts are dry fine powders. They are made like pillular extracts except the drying process is carried farther in order to reduce them to a powdered condition. The drying must be carefully done at a low temperature to avoid injury by heat. After they have been dried and powdered they are weighed (assayed in the case of alkaloidal drugs) and diluted as required to bring them to standard strength. Powdered extracts are easier to dispense than pillular extracts because they do not stick to the containers, they can be more accurately weighed, and they are more constant in their strength than pillular extracts. They should be preserved in well closed containers in a dry place. In contact with moist air they absorb moisture and become sticky. Twelve extracts are official.

Massæ (masses) are soft, solid preparations composed of an active medicinal substance mixed with excipients to form a mass resembling a pill mass. They are used in making pills and two are official.

Pilulæ (pills) are small, solid bodies of a round, ovoid, or lenticular shape, usually weighing from 1 to 5 grains. They contain medicinal matter and are intended to be swallowed whole. A *bolus* is a very large pill and a *granule* is a very small pill. There are certain advantages in administering medicines in pill form as they can be swallowed without mastication, they are adapted for the administration of heavy metallic substances which cannot readily be suspended in liquids, the action of the medicine is slow and is even retarded in some cases until the pill reaches the lower bowel, being in compact form they are easily swallowed, and when coated they are tasteless.

Occasionally pills have to be made by hand and the process of pillmaking consists roughly of three stages, first, making the pill mass, second, dividing

the pill mass, and third, rolling the pill. A pill mass should be sufficiently adhesive to permit rolling of it without falling in pieces; it should be firm enough to retain its shape when rolled and yet not so soft that the finished pills will flatten during the process of drying; it should be plastic enough to be easily rolled; and most important of all, it should be sufficiently soluble in the juices of the intestinal tract to disintegrate and allow the active ingredients to escape and exert their medicinal effect.

Excipients are agents added to the contents of a pill to facilitate its being made into a suitable mass. There are four classes of excipients: Those which are intended to develop adhesiveness and hence act as solvents, as water, alcohol, diluted alcohol, glycerin, and mixtures of water and glycerin; those which are intended to impart adhesiveness, as glucose, syrup, honey, mucilage of acacia, syrup of acacia, mucilage of tragacanth, glycerite of starch, acacia with glucose or honey, tragacanth with glycerin, soap with water, soap with diluted alcohol, extract of malt, confection of rose, etc.; those which are intended to act simply as absorbents of excessive moisture, and, in a few cases to impart adhesiveness to the mass at the same time, as licorice, powdered orris root, powdered tragacanth, powdered elm bark, powdered marshmallow, starch, etc.

After the pill mass is finished it is rolled out and cut into small pieces. Each one of these pieces represents one pill, and it is finished by rolling it between the thumb and fingers, or in the palm of the hand. To prevent them from adhering together, or from sticking to the fingers while rolling them, they may be dusted lightly with any one of the following powders: Rice flour, powdered licorice root, powdered althæa, talcum, lycopodium, or magnesium carbonate. Two pills are official in the U. S. Pharmacopœia.

Pulveres (powders) are combinations of solid drugs in a finely divided state. They may be for internal use or for external application. There are four official powders, all of which are known as compound powders and are for internal use. Powders intended for external application are known as dusting powders, healing powders, etc.

Besides the Pharmacopœial and the National Formulary powders, physicians frequently prescribe other drugs in powder form; these may be composed of one or more active ingredients, or they may be composed of active ingredients mixed with an inert diluent (sugar of milk) to give bulk to the powder. The official powders are usually made by rubbing the ingredients together in a mortar until a thorough mixture is obtained, the ingredients being previously reduced to a fine state of subdivision. Some substances have a tendency to cake when rubbed in a mortar, and these should be mixed on a pill tile. This caking is due to the presence of moisture, and to the fine state of subdivision of the powder. Dusting powders and granular effervescent powders should not be triturated in a mortar because of this caking. Dusting powders should always be sifted after they are mixed.

Powders which contain strong drugs must of necessity be very intimately mixed in order to insure that an overdose is not contained in any one of the powders. In order to mix one or more strong drugs intimately with other parts of the powder the following rule should be followed: Mix the strongest drug with an equal weight of the next most active drug, and after they are intimately mixed incorporate the remainder of the weaker drug, and then gradually add to this mixture the next weaker drug, etc., until all the ingredients are incorporated.

Resinæ (resins) are solid preparations consisting principally of the resinous principles from vegetable drugs. They are soluble in alcohol but are insoluble

in water and are known as *natural resins,* natural plant exudations, and *prepared resins,* those obtained by pharmaceutical processes. Prepared resins usually are made by taking the alcoholic extracts of vegetable drugs obtained by percolation and concentrated by evaporation and pouring them into water or acidulated water when the resinous principles are precipitated. These are then collected, washed, and dried. Resins may also be obtained by distilling natural oleoresins, the volatile oils passing over and leaving behind the resin. Although prepared by the process of extraction as are extracts, resins differ from extracts by containing only those plant principles that are soluble in alcohol and insoluble in water. Two resins are official.

Suppositoria (suppositories) are solid bodies intended for introduction into different orifices of the human body to produce medicinal action. They are of various weights and shapes and melt or soften at body temperature. The vehicles usually employed to carry the medicinal substances are oil of theobroma, glycerinated gelatin, or sodium stearate.

In the preparation of suppositories it is important that the medicinal substance be equally distributed throughout the vehicle. This distribution may be made by rubbing the medicinal substance with the vehicle, or by fusion of the vehicle and incorporation of the medicine with the melted vehicle followed by chilling of the fused mixture in molds. Suppositories are usually prepared by methods known as "hand made or rolled", "molded", and "machine made or pressed".

Suppositories should be of such consistency as to retain their shape until inserted and then quickly melt. Oil of theobroma (cocoa butter) is the ideal vehicle or base for suppositories because it melts at a temperature slightly below that of the body but remains solid at ordinary temperatures. It is also a bland, nonirritating oil. After suppositories have been made they should be kept in a cool place. Rectal suppositories should be cone shaped, and if oil of theobroma is used as the vehicle they should weigh about 2 Gms. Urethral suppositories should be pencil shaped and with a rounded point at one end. When 7 centimeters (2½ inches) long they should weigh 2 Gms., and when 14 centimeters (5 inches) long they should weigh about 4 Gms., if made with glycerinated gelatin as the vehicle. If made with oil of theobroma as the vehicle they should weigh one-half the above amounts. Vaginal suppositories should be ovoid or globular in shape and weigh about 4 Gms. if made with oil of theobroma and 10 Gms. if made with glycerinated gelatin. Only one suppository is official.

Tabellæ (tablets) are solid, small, flattened masses of medicinal powders. They are divided into several classes according to the method of manufacture or the use for which they are intended. Among these classes are the *tablet triturate,* the *compressed tablet,* and the *hypodermic tablet.* The general procedure in making tablets is to first grind, thoroughly mix, and sift the ingredients, next granulate the mixed materials by moistening with a suitable liquid containing a "binder" and passing through a very coarse screen, and then dry the coarse granules. After drying the coarse granules they are reduced to the proper size and the material pressed into the proper size and shape. (For full information concerning tablet making refer to a standard textbook on the Practice of Pharmacy.) Three tablets are official, two of them being the "poison" tablets of mercuric chloride which have a distinctive color, not white, and an angular or irregular shape.

Triturationes (triturations) are a class of powders having a definite relation between the active medicinal ingredient and the diluent. This relation is one

part of the medicinal substance and nine parts of diluent. They are made by adding to the substance, previously reduced to a moderately fine powder if necessary, an equal amount of the diluent, mixing well by means of a spatula, and triturating the powders together in a mortar. The remainder of the diluent is added in portions until the whole is added, triturating after each portion is added, and continuing the trituration until a fine powder is obtained. Sugar of milk (lactose) is prescribed as the diluent, largely because its hardness helps to insure a fine comminution of the medicinal substance. Triturations are excellent forms for the administration of powerful alkaloids. Only the general formula for triturations is official in the Pharmacopœia.

Unguenta (ointments) are semisolid preparations containing medicinal substances blended with fatty matter of sufficient softness to permit their being applied to the skin by inunction. All official ointments are made either by fusion or incorporation; one ointment recognized in the National Formulary, ointment of mercuric nitrate (citrine ointment), is made by chemical reaction. When made by fusion the fatty substances are liquefied by the aid of heat and the medicinal substance incorporated while the fats are liquid or after solidification; when made by incorporation the medicinal substance is rubbed up with the solid fatty matter, either in a mortar or on an ointment slab. In making ointments by fusion ingredients having high melting points should be melted before those having a lower melting point as the high heat necessary to melt the former may be injurious to the latter. Ointments made by fusion should be stirred while cooling, because the ingredients having high melting points usually will solidify first, resulting in a granular ointment. If the medicinal substance used is a powder it should be brought to the finest possible state of subdivision before incorporating it with the ointment base.

According to their therapeutic use, ointments may be classified as *nonabsorbable*, those which act as protectives and produce their medicinal effects on the epidermis or outer skin; *emollient*, those which soften the epidermis and carry their medicinal effects into the derma or true skin; and *absorbable*, those which penetrate the skin and enter the general circulation producing systemic or constitutional medicinal effects. In order that these therapeutic effects of ointments may be obtained the bases used in the different classes of ointments vary and must be suitable for the purpose intended.

An ointment base should not be rancid, not only because of the peculiarly disagreeable odor but because the volatile fatty acids released when rancidity develops are frequently irritating and may cause chemical reaction. Petrolatum is a good ointment base for almost any purpose except when absorption is desired. Being practically nonabsorbable it is an excellent base for ointments used in treating skin diseases. Hydrous wool fat is a good ointment base, is quite absorbable, perhaps because of the water it contains, and is used especially in making ointments containing liquids which are not miscible with the prescribed base. The U. S. Pharmacopœia allows as much as 30 per cent of water in the official hydrous wool fat, and the presence of that amount of water gives it the proper consistency for use as an ointment base. Anhydrous wool fat is very tough and sticky and for making ointments containing a large amount of water or other liquid its use is preferable to the hydrous wool fat. Yellow wax is better for an ointment base than white, or bleached, wax, because in the process of bleaching the yellow wax a change takes place which makes the white wax more likely to become rancid. The official glycerite of starch is sometimes directed to be used as the vehicle for ointments under the name of *plasma* or *plasma glycerini* because

it is not greasy, can be washed off without difficulty, and never becomes rancid. In making ointment of boric acid it is stirred until congealed, as boric acid is not soluble in petrolatum and is held mechanically.

Glycerin is used in tannic-acid ointment to dissolve the acid and make it more effective. Metal spatulas should not be used in making tannic-acid ointment, as it attacks the iron, forming tannate of iron, resulting in a darkened ointment. If the spatula first is smeared with the fatty substance, there is little danger.

In making cold cream (ointment of rose water) rose water is used instead of oil of roses to perfume it, as the water makes it softer and more creamy. Borax is used in cold cream to give a whiter and more creamy preparation. Water is warmed in making cold cream, because if not warmed it will chill the melted base and make it lumpy or granular. Many cold creams are made with paraffin and liquid petrolatum, as it is a cheaper base and one that does not become rancid.

In making belladonna ointment the extract is rubbed with diluted alcohol to thoroughly soften the extract so as to make a homogeneous mixture. Wool fat then is used to take up the liquid.

Oleate of mercury is used in making mercurial ointment because it will hold mercury in a microscopic state of subdivision. Mercurial ointment should be kept in a cool place, as the mercury separates out when warmed. Metal spatulas should not be used in its making.

Lanolin is better for making yellow oxide of mercury ointment than the simple ointment, as the mercury oxide is not reduced readily.

Potassium iodide is used in iodine ointment, as iodine cannot be reduced to an impalpable powder, but is very soluble in a glycerin solution of potassium iodide, and this solution can be mixed intimately with the base. Glycerin is used in iodine ointment to dissolve the potassium iodide. Water is objectionable because it evaporates and the iodide is left in gritty crystals.

PRESCRIPTIONS

The preparation and dispensing of medicines intended to be compounded extemporaneously or as the occasion or the physician's needs may require is termed *magistral pharmacy.* Under this head is placed the filling of prescriptions.

A prescription is a formula which a physician writes, specifying the substances he intends to have administered to a patient. It is written in the Latin language because that is the official language of science, is understood throughout the world, and, being a "dead" language, is not subject to change. It is sometimes necessary and always advisable that a patient should not know the names and properties of the medicinal agents administered and this is usually possible when Latin is used.

The parts of a prescription are: 1. The name of the patient and the date; 2. The superscription, or heading, indicated by the symbol "℞", standing for the Latin word "Recipe" (take thou); 3. The inscription, or the names and quantities of the ingredients (the base, the adjuvant, the corrective, and the vehicle) to be compounded; 4. The subscription, or the directions to the pharmacist or compounder; 5. The signa (mark) or transcription, or the directions to the patient; 6. The name or initial of the physician.

Model Prescription

℞ For: John Jones 3/15/23

Sodii bromidi	16 Gm.	(ʒiv)
Antipyrinæ	8 Gm.	(ʒ ii)
Liquor acidi arsenosi	4 cc	(fʒ i)
Aquæ menthæ piperitæ—q. s. ad	120 cc	(f ℥iv)

Misce et signa: One teaspoonful in water three times daily after meals.

Richard Doe, M. D.

Before filling a prescription the compounder should read it carefully to judge the safety of the doses of the different ingredients and their compatibility. In law, the pharmacist as well as the physician, is held responsible in case of an overdose, and suit for damages is much more likely to be brought against the pharmacist than the physician.

The words "use as directed" should be avoided by the prescriber as the patient is generally in a more or less nervous condition and likely to forget the details; then, too, having the directions on the prescription makes another safeguard in that pharmacists can detect an error more readily if one is present. Upon the dose depends the safety.

In filling prescriptions requiring the mixture of an insoluble substance with a liquid, it is preferable to rub it in a mortar with a small amount of liquid, because if the solid is put simply into a bottle and shaken the substance may "lump" and require time and agitation in order to get it mixed. This is particularly true with calomel, magnesia, sulfur, or a vegetable drug.

The employment of abbreviations in prescription writing is universal but great care must be taken to avoid abbreviations that might lead to the use of unintended substances and the death of the patient. Some titles of medicinal substances should never be abbreviated. Following is a table of abbreviations of the principal Latin words used in pharmacy with their contraction and meaning:

Term or phrase	Contraction	Meaning
Ad	Ad	To, up to.
Ad conciliandum gustum		To suit the taste.
Adde, addantur, addentum, addendo	Add	Add, let them be added, to be added, by adding.
Ad libitum	Ad lib	At pleasure.
Albus	Alb	White.
Alternis horis		Every other hour.
Ana	ā ā, A	Of each.
Ante cibum	a. c	Before eating, before meals.
Aqua bulliens	Aq. bull	Boiling water.
Aqua communis	Aq. comm	Common water.
Aqua fervens	Aq. ferv	Hot water.
Bene		Well.
Bis		Twice.
Bis in die, Bis in dies	Bis in d., B. i. d	Twice a day.
Capiat	Cap	Let him (or her) take.
Charta	Chart	Paper.
Cibus		Food.
Cochlear or cochleare, Cochleatim	Coch., Cochleat	A spoonful, by spoonfuls.
Cochleare amplum	Coch. amp	A tablespoonful.
Cochleare magnum	Coch. mag	A large spoonful (about half an ounce).
Cochleare medium or modicum	Coch. med	A dessertspoonful (about 2 fluidrams).
Cochleare parvum	Coch. parv	A teaspoonful (about 1 fluidram).
Cola	Col	Strain.
Collunarium		A nose wash.
Collutorium	Collut	A mouth wash.
Collyrium	Collyr., Col	An eye wash.
Congius	Cong	A gallon.
Contra		Against.
Cortex	Cort	The bark.
Cum	C	With.

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Term or phrase	Contraction	Meaning
Dividatur in partes æquales	D. in p. æq	Let it be divided into equal parts.
Eadam (fem)		The same.
Ejusdem	Ejusd	Of the same.
Et		And.
Fac., Fiat., Fiant	F., Ft	Make, let it be made, let them be made.
Fiant chartulæ xii	Ft. chart. xii	Let 12 papers be made.
Fiant pilulæ xii	Ft. pil. xii	Let 12 pills be made.
Fiant pulveres xii	Ft. pulv. xii	Let 12 powders be made.
Fiat secundum artis regulas	F. S. A. R	Let it be made according to the rules of art
Fiat solutio	Ft. solut	Let a solution be made.
Filtra		Filter (thou).
Flavus	Flav	Yellow.
Gargarisma	Garg	A gargle.
Gutta	Gtt	A drop.
Guttatim	Guttat	By drops.
Idem		The same.
Misce	M	Mix.
Non		Not.
Non repetatur	Non rep	Do not repeat.
Octarius	O	A pint.
Partes æquales	P. æ	Equal parts.
Post cibo	p. c	After eating.
Pro re nata	P. r. n	Occasionally.
Pulvis	Pulv	A powder.
Quantum sufficiat, Quantum satis	Q. S	As much as is sufficient.
Secundum artem, Secundum naturam	S. A., S. N	According to art, according to nature.
Semis	Ss	A half.
Signa	Sig., S	Mark thou.
Solve		Dissolve.
Supra		Above.
Ter in die	T. i. d	Three times a day.
Ultimo (or ultima) præscriptus	Ult. præsc	The last ordered.
Uncia		An ounce.
Ut dictum	Ut Dict	As directed.

INCOMPATIBILITY

Incompatibility is a term used in Pharmacy to describe conditions in which drugs used in pharmaceutical mixtures will not combine, produce new compounds, or are therapeutically opposed. These conditions are known as pharmaceutical, chemical, and therapeutic incompatibility.

Chemical incompatibility is chemical action resulting in the decomposition of one or more of the ingredients entering into the prescription. It may result in precipitation, production of a gas, in a change in color, or in explosive or poisonous compounds, and is sometimes intentional. Examples: Alkaloids will be precipitated from their solution by tannic acid, alkalies, carbonates, iodine or iodides, phosphates, boric acid, and borates. Explosive compounds will result from mixing powerful oxidizing agents with others which are readily oxidizable, such as nitric or nitrohydrochloric acids, potassium chlorate, or potassium permanganate with glycerin, sugar, alcohol, oils, ethers, tannin, sulfur, sulfides, phosphorus, and hypophosphites. Glucosides are decomposed with substances containing emulsin. Iron salts with tannic acid or drugs containing tannin produce inky mixtures.

Pharmaceutical incompatibility (also known as physical incompatibility) is the condition arising from attempting the mixture of pharmaceutical preparations or ingredients which are physically repellent to each other and results in the physical dissociation of one or more constituents, but without chemical action. Examples: Tincture of chloride of iron added to syrup of acacia will gelatinize; fluidextracts diluted with liquids differing from those used in the fluidextracts cause the gum, albumin, resin, or mucilage to separate. Water is the solvent for albuminous, gelatinous, gummy, and saccharine bodies and for a large number of inorganic salts, while alcohol is the solvent for volatile oils and resins, gum resins, resinoids, balsams, and all drugs containing these sub-

stances as their active principles. The solvent power of either alcohol or water for the particular substance decreases in proportion to the amount of one added to the other.

Therapeutic incompatibility occurs when two agents antagonistic to each other in their action in the human system are given together. Examples: Belladonna in any form with physostigmine; a solution of bromide of potash with strychnine; opium with caffeine.

In many cases physiological antagonists intentionally are given together so that one will act as a guard against the excessive action of the other, as the use of morphine with atropine.

THE HARRISON NARCOTIC LAW

The Harrison narcotic law, enacted by the United States Congress December 17, 1914, provides that on or after March 1, 1915, every person who imports, manufactures, produces, compounds, sells, deals in, dispenses, or gives away opium and coca leaves or any compound, manufacture, salt, derivative, or preparation thereof, shall register with the collector of internal revenue of his district his name or style, place of business, and place or places where such business is carried on. The provisions of this act are not construed to apply to the sale, distribution, giving away, dispensing, or possession of preparations and remedies which do not contain more than 2 grains of opium, or more than one-fourth of a grain of morphine, one-eighth of a grain of heroin, or more than 1 grain of codeine, or any salt or derivative of any of them in 1 fluidounce, or, if a solid or semisolid preparation, in 1 avoirdupois ounce, or to liniments, ointments, or other preparations which are prepared for external use only, except liniments, ointments, and other preparations which contain cocaine, * * * etc., provided that such preparations are manufactured, sold, distributed, given away, dispensed, or possessed as medicines and not for the purpose of evading the intentions and provisions of this act. A Federal law was later passed which prohibits the importation of heroin and of opium for the manufacture of heroin.

Paragraph 736, Manual of the Medical Department, U. S. Navy, concerns the prescription of narcotic drugs.

GENERAL PRECAUTIONS IN REGARD TO DISPENSING

In filling prescriptions for eye solutions the greatest care should be taken not only in accurately weighing and measuring the amounts called for, but also in maintaining scrupulous cleanliness. See that all containers and utensils are absolutely clean. All eye solutions and eye washes should be filtered through a high grade of filter paper, and distilled water only should be used in making them. These precautions also apply in making solutions for hypodermic injection, such as procaine and cocaine solutions.

Be careful when giving out medicine that the correct drug in correct dosage is being given. Before putting any medicine in the eye or injecting any solution into the uretha, rectum, or other body opening one should be sure that the solution is of the *proper strength and temperature.* Care should also be exercised as to ointments and medicaments for application to the skin that they are of the right strength. Nothing so reflects on the Medical Department, and on the individual hospital corpsman who has made the mistake, as an error in which a patient seeking assistance has been made worse or seriously or fatally injured by a poisonous dose of a drug. The greatest care therefore should be exercised in the preparation and giving out of all medication.

It is also desirable to display an appropriate warning sign in red over the prescription counter to further draw attention to the danger of preparing and dispensing poisonous doses of any drug.

HINTS IN PRACTICAL PHARMACY

PRESCRIPTIONS

1. Read the prescription carefully, noting the quantity of each ingredient.
2. Do not hesitate to ask if in doubt about the name of a certain drug, proper weight, or dose.
3. Check the weight of each ingredient.
4. Make certain that the balance is in balance.
5. Check off with pencil the name of each ingredient on the prescription in the process of compounding.
6. Do not weigh the ingredients on the bare scale pan. Always place a piece of pan-paper on each pan and again balance the balance.
7. After the prescription has been compounded make such notes on it as may be necessary so there will be no likelihood of the renewed prescription differing from the original.
8. Request the medical officer to initial any change in the prescription he may have ordered.
9. Reduce to a fine powder all crystalline salts before admixture.
10. Do not strain out any insoluble medicinal substance unless directed by the medical officer.
11. If the prescription contains any insoluble matter, dispense it with a "shake" label.
12. All hypodermic solutions and eye lotions should be filtered.
13. Clear solutions containing "specks" or accidental impurities should be strained through absorbent cotton.
14. In making dusting powders pass the material through a No. 80 sieve to insure greater uniformity and fineness.
15. In folding powders avoid having any medicinal substance in the folds of the powder paper.

PILLS

16. Use a white excipient in making light pills with corn starch or rice powder as a dusting powder.
17. When making dark pills use a dark excipient such as extract of gentian, with lycopodium as a dusting powder.

NOTE.—When making pills containing oxidizable substances such as potassium permanganate, silver nitrate, etc., use cocoa butter as an excipient.

18. The maximum weight of the average pill should not exceed 5 grains.
19. Always use the proper utensils in making pills—shallow mortar, flat pestle, stiff broad spatula, glass tile, pill machine and finisher (if available.)

EMULSIONS

20. A whiter emulsion is obtained when acacia is used as an emulsifying agent.
21. Tragacanth is preferred as an emulsifying agent in emulsions containing alcoholic mixtures.
22. Do not use tincture of soap bark as an emulsifying agent as it exerts some physiological action.
23. Solution of potash or soda must not be used. The finished product will be a soap and *not* an emulsion.

24. The mortar must be perfectly dry when making an emulsion.

25. Add water very slowly to the "primary emulsion," or nucleus, to prevent cracking.

26. Wedgwood mortars are preferred in making emulsions.

27. Use the "Bottle" method in making emulsions containing volatile oils.

28. Remember the proportions in making an emulsion of a fixed oil by the Continental method: Oil, 4 parts; water, 2 parts; gum, 1 part.

29. In making the nucleus of an emulsion of a volatile oil the proportions are: Oil, 4 parts; water, 2 parts; gum, 1 part.

OINTMENTS

30. Do not use a rancid ointment base.

31. Use anhydrous wool fat in making ointment containing a large amount of water or other fluid.

32. Use benzoinated lard in making ointments to retard rancidity.

33. The medicinal agents must first be mixed with a small portion of the base to insure a smooth finished product.

34. Ointments intended for application to the eyes should be mixed in a glass mortar.

35. Never use the fusion method in making sulfur ointment—the sulfur is precipitated. Avoid using too much heat in making any ointment.

36. In making boric-acid ointment stir until congealed, because the boric acid is held in the petrolatum mechanically.

37. Do not use an iron spatula in making iodine or tannic-acid ointments.

38. Use warm water in making cold cream to prevent a lumpy or granular product.

39. Diluted alcohol should be used in making belladonna ointment to soften the extract.

40. Reduce the iodine to an impalpable powder with the aid of a glycerin solution of potassium iodide in making iodine ointment.

41. Use water to dissolve the potassium iodide in making the ointment of this salt.

CAPSULES

42. It is desirable to seal hard capsules containing liquid medicine.

43. Sealing hard capsules is accomplished by pressing the cap upon a small piece of absorbent cotton saturated in hot water or diluted alcohol.

44. Before dispensing always rub the filled capsule between the folds of a towel or piece of gauze to remove any powder clinging to the outside.

45. In filling capsules, fill the body of the capsule and not the cap.

GENERAL HINTS

46. Waxed or parchment paper should be used when dispensing medicine that is hygroscopic or is likely to change in the air.

47. Do not triturate potassium chlorate with organic matter. There is danger of an explosion.

48. The only way camphor can be powdered is by addition of a small quantity of alcohol.

49. Always put the tartaric acid of the Seidlitz powder in the white paper to prevent the acid from becoming colored.

50. Keep tincture of iron in a colored bottle and protected from light, as light reduces the iron.

51. Use blue-colored bottles for poisonous liquids or liquids intended for external use.

52. Every medicinal substance sent out from the dispensary must have a neat and distinct label upon it.

53. It is good pharmaceutical practice always to attach a poison label when dispensing medicines containing poisons.

54. Attach "local use" labels to eye lotions and mouth washes and "external use" labels to liniments.

55. Never dispense an emulsion or mixture containing insoluble material without a "shake" label.

56. Always remember the five cardinal points in labeling a prescription— 1. Patient's name and rating; 2. Date; 3. Number; 4. Directions; and 5. Medical officer's signature.

57. In refilling prescriptions thoroughly clean the soiled containers. Affix a new label and in case of a bottle use a new cork.

58. Two hospital corpsmen should check prescriptions when possible.

59. If the man who compounds a prescription is required to check his own work, he should keep on the counter all the containers from which he takes the ingredients until the prescription is compounded. Then proceed to check off each item and its quantity.

60. If in doubt as to just what was used or the quantity used, throw away the entire prescription and start again. It is better to lose some material than to dispense the wrong medicine.

61. Paste the label evenly on the front of the bottle, a little above the center. All bottles, even round ones, have a front. Avoid an excess of paste. To smooth the label on the bottle place a piece of clean paper over it and rub. To make labels stick on tin, coat the tin first with a thin layer of tincture of benzoin (or any resinous substance) and let dry. Then apply paste and, lastly, the label.

62. Be neat in dispensing. Be sure that utensils and bottles are clean, corks are whole, and that packages are wrapped neatly.

63. Do not forget the proper cleaning of a mortar or graduate which has been used with oil or ointment; the excess may be easily removed by wiping out with sawdust or newspaper.

64. A handy twine holder is a small funnel suspended in a convenient place. Place the ball of twine inside and run the end of the string through the funnel end.

SOLUTION TABLE SHOWING THE QUANTITY OF DRUG IN GRAINS TO USE IN PREPARING AQUEOUS SOLUTIONS OF VARIOUS STRENGTHS

Apothecaries measure. (1 FLUIDOUNCE WATER WEIGHS 456 GRAINS)

Fluidounces of solution	1/5,000	1/4,000	1/3,000	1/2,000	1/1,000	1/500	½ per cent	1 per cent	2 per cent	3 per cent	4 per cent	5 per cent	10 per cent	20 per cent	25 per cent	50 per cent
½	0.0456	0.057	0.0760	0.114	0.228	0.456	1.14	2.28	4.56	6.84	9.12	11.4	22.8	45.6	57	114
1	.0912	.114	.1520	.228	.456	.912	2.28	4.56	9.12	13.68	18.24	22.8	45.6	91.2	114	228
2	.1824	.228	.304	.456	.912	1.824	4.56	9.12	18.24	27.36	36.48	45.6	91.2	182.4	228	456
3	.2736	.342	.456	.684	1.368	2.736	6.84	13.68	27.36	41.04	54.72	68.4	136.8	273.6	342	684
4	.3648	.456	.608	.912	1.824	3.648	9.12	18.24	36.48	54.73	72.96	91.2	182.4	364.8	456	912
6	.5472	.684	.912	1.368	2.736	5.472	13.68	27.36	54.72	82.08	109.44	136.8	273.6	547.2	684	1,368
8	.7296	.912	1.216	1.824	3.648	7.296	18.24	36.48	72.96	109.44	145.92	182.4	364.8	729.6	912	1,824
12	1.0944	1.368	1.824	2.736	5.472	10.944	27.36	54.72	109.44	164.16	218.88	273.6	547.2	1,094.4	1,368	2,736
16	1.4592	1.824	2.432	3.648	7.296	14.592	36.48	72.96	145.92	218.88	291.84	364.8	729.6	1,459.2	1,824	3,648

SOLUTION TABLE SHOWING THE QUANTITY OF DRUG IN GRAMS TO USE IN PREPARING AQUEOUS SOLUTIONS OF VARIOUS STRENGTHS

Metric measure

Cubic centimeters of solution	1/5,000	1/4,000	1/3,000	1/2,000	1/1,000	1/500	½ per cent	1 per cent	2 per cent	3 per cent	4 per cent	5 per cent	10 per cent	20 per cent	25 per cent	50 per cent
10	0.002	0.0025	0.0033	0.005	0.01	0.02	0.05	0.1	0.2	0.3	0.4	0.5	1	2	2.5	5
25	.005	.00625	.0083	.0125	.025	.05	.125	.25	.5	.75	1	1.25	2.5	5	6.25	12.5
50	.01	.0125	.0167	.025	.05	.1	.25	.5	1	1.5	2	2.5	5	10	12.5	25
75	.015	.01875	.025	.0375	.075	.150	.375	.75	1.5	2.25	3	3.75	7.5	15	18.75	37.5
100	.02	.025	.033	.05	.1	.2	.5	1	2	3	4	5	10	20	25	50
200	.04	.05	.067	.1	.2	.4	1	2	4	6	8	10	20	40	50	100
300	.06	.075	.10	.15	.3	.6	1.5	3	6	9	12	15	30	60	75	150
400	.08	.1	.133	.2	.4	.8	2	4	8	12	16	20	40	80	100	200
500	.1	.125	.167	.25	.5	1	2.5	5	10	15	20	25	50	100	125	250

CHAPTER IX

CHEMISTRY

GENERAL INTRODUCTION

Man lives in a world of material, and his body is of a material nature. This material occurs in an infinite variety of forms and is generally spoken of as matter. On the basis of the natural physical form of its occurrence matter is classed as *solid*, *liquid*, or *gaseous*, and on the basis of its structure it is classed as *organic* and *inorganic*.

Animal and plant forms of matter are vitalized by a force called life and are endowed with the power to grow, to assimilate other matter, to reproduce their kind, and to react to environmental stimuli. Such matter is classed as organic or living and a clear understanding of the differentiation between organic and inorganic forms of matter is essential to a proper appreciation of the science of chemistry. Plant life, through the action of sunlight on chlorophyll, has the exclusive power to extract carbon from the air and to change and combine it in the complex forms needed by the plant structure. This is the origin of organic matter. Plant organic matter may decompose with liberation of the carbon contained in it, may be preserved as inanimate organic matter, of which coal is an example, or it may be assimilated by some form of animal life and become animal tissue. This animal-tissue carbon is subject in turn to the same fate, and eventually becomes available for the support of plant life.

An aquarium is a familiar example of the fundamental part carbon plays in organic life. When the plant life and fish in the aquarium are properly balanced in quantity of each, the aquarium can be sealed off from the outside air without suffocating either form of life. The fish produce carbon dioxide as a waste product; the plant life takes up this gas, separates the carbon and oxygen, utilizes the carbon for plant growth and discards the oxygen which the fish need. Then the fish eat plant forms to get carbon in organic forms.

Plant life and animal life, therefore, supplement each other. The general processes of utilizing the carbon and oxygen are known as plant and animal physiology. The means employed to effect this utilization are chemical. Nature still remains the master chemist and man has devoted much time, effort, and study to discover the secrets of Nature's chemical processes and to attempt to duplicate them. The study of the chemical processes of living matter is termed *organic chemistry.*

In contrast, *inorganic chemistry* is concerned with mineral matter which does not contain carbon and does not originate from a vital process. Actually this differentiation needs qualification because organic compounds have been synthesized in the laboratory and there are rare inorganic compounds that contain carbon.

Through the many centuries of man's existence he has manifested an attitude of curiosity towards the unknown which has provided him with a fertile field for exploration. He developed special senses which allowed him a fairly

safe and comfortable existence with his environmental material. These senses helped him detect and utilize beneficial material and warned him of dangerous matter. This classification of matter was sufficient for his purpose but the nature or composition of matter has become a major source of interest. At any given period some facts about matter were known to man and he resorted to mystic and philosophical speculation to account for the other characteristics of matter. The rewards to the successful have brought immortality to the names of the adventurers and their discoveries have been stepping stones in the progress of the human race.

The ancient Greeks were familiar with gold, silver, iron, and copper, and developed alloys of these elements. Although they had no idea that these metals represented elemental material their ignorance did not prevent them from employing these metals and other matter in a very practical form. The Romans added mercury, tin, and lead to this list of elements.

The ancient Egyptians, Chaldeans, Hindus, and Chinese, were also familiar with many processes involving the transformation of materials as is evidenced by the mechanical separation of gold, the smelting of iron, the preparation of metallic alloys, and the manufacture of glass, pottery, and enamel ware, and animal and vegetable dyes.

Until Greek philosophers, about the fifth century B. C., began to speculate upon the origin of the universe and the constitution of matter, these ancient peoples had shown no desire to investigate the nature of the chemical processes by which they made new materials from other materials; they were concerned only with the practical application of these processes. Aristotle (384–322 B. C.) believed that all matter was composed of various proportions of four simple bodies or elements, earth, air, fire, and water, to which he added a fifth, the *quintessence*, that acted as a carrier for the four fundamental properties of matter, hotness, coldness, dryness, and moistness. He also believed in the possibility that one form of matter could be changed into another by altering the amounts of the elemental qualities.

The ancient Egyptians were highly skilled in the application of many chemical processes and their practical knowledge became mingled with the speculative theories of the Greeks following the conquest of both peoples by the Romans. From this mingling of knowledge at about the beginning of the Christian era, is believed to have originated the idea of the transmutation of metals, such as the conversion of base metals into gold.

The Arabs, about the seventh century A. D., translated many Greek works on chemistry, effectively united Greek theory and Egyptian practice, and produced a definite system of chemistry in which experiment and theory were correlated. Although the Arabs added but little to existing chemical knowledge they systematically studied the properties of substances and classed all bodies as animal, vegetable, or mineral. Several chemical words, such as *alchemy, alcohol, alembic, alkali,* and *borax,* are Arabic in origin. It appears that the Arabs also studied the chemistry of organic substances. One of the foremost chemists of the Arabian period appears to have been Geber (721–813 A. D.), who was familiar with the processes of crystallization, calcination, distillation, filtration, and reduction. He was also familiar with sulfuric acid, ammonium chloride, arsenous acid (arsenic trioxide), and mercurous chloride (calomel), and was acquainted with acetic and citric acids.

Following the decline of Arab learning about 1200 A. D. the study of alchemy, as chemistry was then termed, spread to Europe where, during the Middle Ages, it was strongly influenced by religion, mysticism, and the doctrines of Aristotle and transmutation. During the next four centuries the chief interest

of the alchemists centered in the attempt to discover the *philosopher's stone* or the *stone of wisdom* by which they could make gold out of base metals. They also sought the *elixir vitæ*, supposed to be the sovereign remedy which would cure all disease and prolong life. Although no gold was produced and the sovereign remedy was not found, much valuable knowledge of chemical processes was gained, many new and important substances were discovered, and apparatus and methods were perfected as incidental by-products. Today thousands of tons of some of the substances discovered by the alchemists are made and used every year. The efforts which produced these results cannot be classed as scientific for they represented random explorations conducted without compass or guide.

The influence of Paracelsus (1493–1541 A. D.) caused chemistry to become closely allied with medicine, and during the sixteenth and seventeenth centuries it was known as iatro-chemistry, *iatros* being a Greek word meaning physician.

During this period chemistry appears to have been applied principally to the production and purification of drugs for medicinal use and to the investigation of their composition and action. Many chemical facts were accumulated by the iatro-chemists and standards of chemical purity and chemical individuality were developed.

Living during this period were many men whose names will ever be associated with chemistry. A few of them were Libavius (1540–1616), Van Helmont (1577–1644), Francis de la Boë (1614–1672) (better known as Sylvius), Agricola (1494–1555), Palissy (1510–1589), and Glauber (1604–1668).

Robert Boyle (1627–1691) was probably the first to study chemistry as a science, and as a science chemistry dates back only to him. His studies were with a view "to find out Nature, to see into what principles things might be resolved, and of what they were compounded." Until the advent of Boyle there was no sound system of scientific theory based on experiment. He it was who brought into use analytical methods of determining the composition of substances, and by his work, in which he strictly observed scientific method, he cleared chemistry of the false doctrines of the alchemists and iatro-chemists. The use of indicators in detecting acids and alkalis is due to him; he differentiated between mixtures, elements, and compounds; and stated that elements are substances that cannot be split up into other substances. Boyle is best known perhaps for his development of the physical laws governing the conduct of gases.

As a result of Boyle's scientific work chemistry as a science gained a firm foundation and began to progress along rational lines. Following him came Lavoisier (1743–1794) who is credited with the modern oxygen theory of combustion and with whom begins modern chemistry; Cavendish (1731–1810), who demonstrated the composition of air, water, and nitric acid; Scheele (1742–1786) who discovered oxygen and chlorine, and, with Priestly (1733–1804), many new gases; and Black (1728–1799) who originated the theory of latent heat and demonstrated the precise difference between carbon dioxide and air.

Lavoisier's scientific work largely established the foundations of modern science and he completely overthrew the phlogiston theory of combustion. According to this theory a suppositional substance called phlogiston escaped into the air during combustion, and this implied that the substance remaining after burning weighed less than before burning. Boyle had recognized that the opposite was true, and in 1784 Lavoisier proved conclusively that combustion is a rapid chemical combination of a substance with oxygen, and that but one of the two principal gases composing air was consumed in combustion. To

the gas consumed in combustion he gave the name oxygen; the other he called *azote* which was later to become nitrogen.

By these discoveries chemistry was definitely established as a science separate from physics, although both deal with the nature of matter, are closely related, supplement each other, and overlap considerably in their fields of investigation. In general, physics is concerned primarily in comparing various material forms with the object of discovering characteristics common to both, and Boyle's discovery concerning gases actually was in the realm of physics.

Chemistry deals with the characteristics peculiar to any given form of matter. It therefore endeavors to break down material into its basic elements, identify them, and determine what peculiarity differentiates a particular form of material from all other forms. The discovery of the atom, the identification of the atoms characteristic of the different elements, and their reactions became the task of the chemist. The idea that all matter is composed of some fundamental unit dates back to at least the fifth century, B. C., when Democritus not only proposed this theory but even christened this unit the "atom" which means indivisible.

John Dalton (1766–1844), an English chemist and physicist, developed an atomic theory very different from that of the ancients. He propounded that all matter consisted of atoms; that atoms are indestructible, indivisible, and differ in their nature and properties; that atoms of the same element have the same weight and properties; and that atoms of elements combine with atoms of other elements to form compounds. His table of atomic weights was first published in 1807 and his theory of the atom in 1808. This theory of Dalton's produced a great influence on the advancement of chemical knowledge, and, with the work of Lavoisier, may be said to form the basis of modern chemistry. The theory, no longer used entirely as propounded, still serves some practical purposes.

About 1900 the *atom* was accepted as the basic unit of structure for matter. Seventy-five elemental atoms had then been identified and on the basis of the Periodic Table, 92 were regarded as theoretically possible. The atom of each element was regarded as a complete, indivisible unit peculiar to that element, and it was found that, as Dalton had postulated, these atoms differed from other atoms in weight and valence (combining power, or affinity; *see* p. 664). Combinations of atoms are known as *molecules* and an almost infinite variety of molecules is possible. It was discovered that the atoms of any element always combined with a definite number of atoms of another element. Helium lacks affinity for any other atom and it therefore remains uncombined chemically and has a valence of zero. The hydrogen atom which is the lightest atom by weight and was formerly used as the standard for comparison in determining the weight of other atoms, is the standard for the determination of valence. Hydrogen, with a valence of one, will unite atom for atom with atoms of like valence; for example, one atom of hydrogen unites with one atom of chlorine to form a molecule of hydrochloric acid. Any atom of oxygen, which has a valence of two, will combine with two atoms of hydrogen to form a molecule of water; any atom of nitrogen with a valence of three, will combine with three atoms of hydrogen to form a molecule of ammonia gas.

As atoms are the substance of which matter is composed, they must have weight and occupy space. Dalton investigated these properties of the atom and summed up the results of his investigations in two laws which bear his name and will be discussed later.

Atoms do not occur in Nature as such but in the form of molecules, and to designate them letters taken from the names of the elements are used. These

letters are termed symbols (*see* p. 661) and when used alone refer to the atom of the element, but by placing figures before or after the letters the number of the atoms or of the molecules of an element present in a substance may be shown. Thus, "O" indicates one atom of oxygen, "2O" two atoms of oxygen, "O_2" a molecule of oxygen, and "$2O_2$" two molecules of oxygen.

For all practical purposes elements are considered to be substances which cannot be resolved (split up) into or built up from anything simpler. This means that an element is a substance from which no other substance can be extracted and which cannot be made from other substances. Water can be separated into hydrogen and oxygen, air can be separated into oxygen, nitrogen, and other gases, and salt can be separated into sodium and chlorine; therefore they *are not* elements. But the substances into which water, air, and salt can be resolved *are* elements because it has never been possible to obtain any other substance from them or to make them from other substances. It has happened in the past that following improvement in analytical methods, substances considered to be elements have been found to be compounds, and the same may happen again.

In studying the elements it is customary to classify them as *metals* and *nonmetals* and to group them according to the similarity of chemical properties they exhibit. These groups are known as the halogen family, the nitrogen family, the alkali family, the inert gases, etc. Properties in which the elements may show similarity are natural physical form (solid, liquid, or gaseous), tendency to form acid or basic compounds, valence, tendency to combine with other atoms or remain inert, etc.

Following the grouping of elements in families suggestions to classify the elements on the basis of their atomic weights had been made by various investigators who had traced numerical sequences among the atomic weights of some of the elements and noted connections between them and the properties of the different substances. In 1863 Newlands (1838–1898), an English chemist, published his conception of the periodicity of the elements which showed that if the elements be arranged in the order of their atomic weights those having consecutive numbers frequently either belonged to the same group or occupied similar positions in different groups. He also pointed out that each eighth element starting from a given one was a kind of repetition of the first. His idea was ignored or treated with ridicule as fantastic and not worthy of serious consideration.

Newland's idea led to further investigations by a Russian chemist, Mendeléef (1834–1907), who is perhaps best known for his work on the Periodic Law. By 1850 about 60 elements had been identified and their atomic weights determined. Mendeléef noted the similar characteristics of these elements and when he placed them in series according to their atomic weights he found that these characteristics tended to repeat themselves in an orderly fashion in these series. He recognized that these properties of the elements were a periodic function of their atomic weights and on this basis he evolved his *periodic classification of the elements* which he published in 1869 and which, in revised form, is still in use. He did not consider this merely as a system of classifying the elements according to certain observed facts but as a law of Nature which could be relied upon to predict new facts and to disclose errors in what were believed to be true facts. This classification of Mendeléef indicated the probable existence of about 92 elements and permitted predicting the characteristics of missing and hypothetical elements with surprising accuracy. The existence of many of these then unknown elements has also been confirmed.

SERIES	Group 0	Group I — R₂O	Group II — RO	Group III — R_2O_3	Group IV RH_4 RO_2	Group V RH_3 R_2O_5	Group VI RH_2 RO_3	Group VII RH R_2O_7	Group VIII		
1		H 1 1.0078									
2	He 2 4.002	Li 3 6.940	Be 4 9.02	B 5 10.82	C 6 12.01	N 7 14.008	O 8 16.0000	F 9 19.00			
3	Ne 10 20.183	Na 11 22.997	Mg 12 24.32	Al 13 26.97	Si 14 28.06	P 15 31.02	S 16 32.06	Cl 17 35.457			
4	A 18 39.944	K 19 39.096	Ca 20 40.08	Sc 21 45.10	Ti 22 47.90	V 23 50.95	Cr 24 52.01	Mn 25 54.93	Fe 26 55.84	Co 27 58.94	Ni 28 58.69
		Cu 29 63.57	Zn 30 65.38	Ga 31 69.72	Ge 32 72.60	As 33 74.91	Se 34 78.96	Br 35 79.916			
5	Kr 36 83.7	Rb 37 85.48	Sr 38 87.63	Y 39 88.92	Zr 40 91.22	Cb 41 92.91	Mo 42 96.00	Ma 43 99	Ru 44 101.7	Rh 45 102.91	Pd 46 106.7
		Ag 47 107.880	Cd 48 112.41	In 49 114.76	Sn 50 118.70	Sb 51 121.76	Te 52 127.61	I 53 126.92			
6	Xe 54 131.3	Cs 55 132.91	Ba 56 137.36	Rare Earths * Nos. 57–71	Hf 72 178.6	Ta 73 180.88	W 74 184.0	Re 75 186.31	Os 76 191.5	Ir 77 193.1	Pt 78 195.23
		Au 79 197.2	Hg 80 200.61	Tl 81 204.39	Pb 82 207.21	Bi 83 209.00	Po 84 210	Ab 85 219			
7	Rn 86 222	Vi 87 225	Ra 88 226.05	Ac 89 227	Th 90 232.12	Pa 91 231	U 92 238.07				

* RARE EARTHS:														
La 57 138.92	Ce 58 140.13	Pr 59 140.92	Nd 60 144.27	Il 61 146	Sm 62 150.43	Eu 63 152.0	Gd 64 156.9	Tb 65 159.2	Dy 66 162.46	Ho 67 163.5	Er 68 167.64	Tm 69 169.4	Yb 70 173.04	Lu 71 175.0

FIGURE 149.—Periodic Arrangement of the Elements. (U. S. Naval Medical School.)

[NOTE.—Atomic numbers are shown in black-faced type at right of symbols and 1937 International Atomic Weights are shown beneath symbols]

In this periodic classification, usually called the Periodic Table (fig. 149), the elements were formerly arranged in groups and families according to their atomic weights. It later became apparent that in that arrangement certain irregularities existed and recent studies have shown that if the elements are arranged according to their increasing atomic numbers most of these irregularities disappear and certain properties appear at regular intervals systematically throughout the table. As a result of this it has been concluded that most of the properties of an element are dependent upon its atomic number. (*See* p. 663.) Most of the metals appear on the left side of the table and their activity increases as their names go down in any column. The nonmetals are located on the right side of the table and their activity increases as their names go toward the top of any column. The most general utilization of this table is in showing the valence relation of the various families.

By referring to figure 149 it will be seen that the symbols of the names of the elements appear in numbered vertical columns and horizontal rows, each column being called a *group* and each row a *series*. The elements in each series are arranged in sequence according to their atomic numbers. The elements in series 2 beginning with element No. 2, helium, all differ markedly from each other, and element No. 10, neon, which is very similar to helium, is therefore placed in series 3, beneath helium, and followed by new elements until element No. 18, argon, is reached, which, because it is an element similar to both helium and neon, begins series 4.

The elements in each vertical column have a more or less pronounced resemblance to each other which is called group resemblance and is especially noticeable in the valence of the elements in any group. Because of the resemblance in valence the elements in a group form oxides, hydroxides, acids, and salts of the same general formula, and the hydrides and oxides of maximum valence are shown in formulas at the top of certain columns, the R in the formula representing any element in the column. It will be noted that in most of the columns the elements are placed on either the right or the left side of the column which is because those elements on the right side of the column resemble each other much more closely in both chemical characteristics and physical properties than they do those on the left side. Thus the elements in a group are separated into such groups, or *families*, as they are called, which usually are named after the first element of the family appearing in a column, as the nitrogen family, the sulfur family, etc. Elements in series 2 and 3 which do not fall distinctly into either family of their group but combine properties of both, are known as type elements because they represent the general characteristics of their group.

In series 4, 5, and 6 appear 18 elements which are divided into 2 rows, one row consisting of 11 elements appearing on the left side of the columns and the other of 7 elements appearing on the right side of the columns. Of the 11 elements in the upper rows of these series 3 are placed in Group VIII because they resemble each other very closely, being metals with almost identical characteristics, and, if arranged as the first three elements in new rows, they would interrupt the regularity of periodic recurrence of properties of the elements already appearing in series 2 and 3. The series containing 18 elements are often spoken of as *long series* and those containing 8 as *short series*.

It is an interesting fact that in the Periodic Table there is no place for the element hydrogen which, while one of the most important of all the elements, seems to have no close relation to any other element and to stand quite alone. Because of its great chemical activity it cannot be placed with the inert gases

in Group O and although it has some characteristics similar to those of the metallic elements in Group I, it is a gas and not a metal and therefore cannot be placed with the elements in Group I.

There are some other irregularities in the Periodic Table which will not be discussed here.

Of even more importance is the fact that Mendeléef's classification presented a fundamental picture of atomic structure. No longer could the elemental atom be accepted as the ultimate form of matter. The table indicated that the atom consisted of variable but definite combinations of some simpler unit of matter, a situation that was distressing to the chemist who had accepted the various elemental atoms as the ultimate form of matter.

This confused state did not begin to clarify until radiology appeared on the scene at the turn of the century. The X-rays were discovered by Roentgen in 1895 and the physicist studied them and discovered that the emanations from the negative or cathode pole of the X-ray arc consisted of a stream of very minute particles much smaller than atoms. In the United States Dr. R. A. Millikan determined the velocity and weight of these particles and discovered that they carried a negative charge of electricity. These were known as cathode rays and it was also known that another form of matter was thrown off from the positive pole. Discovery that different elements produced the same emanations of these particles proved that their basic composition was similar. Next it was demonstrated that the quantity of positive emanations was proportional to the atomic weight of the element under investigation. These discoveries changed the entire chemical picture.

The atom is now postulated as a structure similar to the solar system of which the Earth is a part. At its center is a core or nucleus consisting of particles charged with positive electricity called *protons* and other particles bearing charges of negative electricity called *electrons*, both occurring in pairs. The characteristics of an atom are due to the number and arrangement of these pairs of protons and electrons, which, in a normal atom, are equal in number, and the total charge of positive electricity therefore neutralizes the total charge of negative electricity. All protons and usually about 50 per cent of the electrons are located in the nucleus. The other electrons are relatively at a great distance from the nucleus and rotate around it in definite orbits, as the planets rotate in orbits around the sun, and are called "planetary" or rotating electrons. Consequently the space occupied by an atom is relatively as free from substance as is the solar system. This explains the phenomenon of the penetrating power of the X-rays in the body and even in iron. That is, they penetrate because they fail to collide with either protons or electrons in their transit through space.

The proton has about 1,850 times the mass of the electron and determines the mass or weight of the atom. So large is the mass of a proton as compared with the mass of an electron that the mass of the atom of any element is approximately proportional to the number of protons in the atom. The simplest atom, that of the element hydrogen, consists of only one proton with one "planetary" electron. In contrast the atom of the element uranium has 238 protons in its nucleus and its specific gravity is approximately that of gold. It is possible to estimate the number of protons in any atom by comparing the known value of its atomic mass with that of hydrogen with its one proton.

The total "planetary" or rotating electrons located in the orbits of an atom determine its atomic number, or position, in the Periodic Table, while those located in the outermost orbit usually determine its valence. The outermost

orbit is termed the valence orbit, and the electrons in this orbit are called valence electrons.

The chemical properties of an atom are very largely due to the "planetary" electrons. As the atomic weight of an atom increases the number of "planetary" electrons also increases. The hypothetical position of the "planetary" electrons is in a series of orbits around the nucleus, the greatest number of orbits being seven. The helium atom has only 2 "planetary" electrons which rotate in a single orbit. Helium and hydrogen are the only 2 elements whose atom has but 1 orbit. Additional electrons assume positions in orbits outside of the original or innermost orbit. The number of rotating electrons in an orbit varies according to the atom of the element, and the maximum number of electrons which may be in any 1 orbit also varies. This arrangement of nucleus and orbits is known as the *octet theory* and has the virtue, at least, of proposing an atomic structure that harmonizes with the Periodic Table. In the first or innermost orbit there may be no more than 2 rotating electrons, in the second no more than 8, in the third no more than 18, in the fourth no more than 32, in the fifth and sixth, with two exceptions (mercury and lead), no more than 18, and in the seventh or outermost no more than 8.

The atom of an element may, therefore, be regarded as being composed of a definite number of pairs of protons and electrons arranged in a definite fashion and reacting in a characteristic manner. The atom has functioned so effectively as a unit of matter that only comparatively recently has its complex structure been demonstrated or even suspected.

The atoms of some elements, as lithium, boron, and lead, differ in their atomic mass although their chemical properties are the same. The difference in mass is due to there being different numbers of protons in the atoms. Atoms having the same chemical properties but different atomic masses are termed *isotopes*, and evidence now shows that many elements are mixtures of isotopes. Radium B, radium D, thorium B, and actinium B are all isotopes of lead and of one another.

From facts brought out in the introduction it is possible to define **chemistry** as *the science which treats of the composition of matter when considered as composed of either electrons, atoms, or molecules; and of the changes which modify or alter the composition of matter*. When two or more substances combine to form a new substance, or substances are divided into their elementary components, the resulting products exhibit entirely new characteristics and are incapable of identification with the original.

As previously stated the science of chemistry is separated into two main divisions on the basis of the structure of matter. These divisions are **inorganic chemistry**, which *is the study of the elements, their properties, applications, and chemical combinations*, and **organic chemistry**, which *is the study of carbon compounds as found in, or as by-products of, living organisms.*

Applied chemistry has many special branches depending upon the industry or profession in which it is employed, i. e., physiological, pharmaceutical, industrial, etc.

By observing the infinite variety of forms in which matter occurs in Nature, and the constant changes taking place, the unlimited applications of chemistry are obvious. The changes which occur in matter may be *physical* or *chemical*, and the earliest knowledge of chemistry was obtained by observing the changes continuously occurring in Nature but it was not until man began to experiment on the substances of Nature that his chemical knowledge made progress. In the performance of his experiments man found certain conditions were

invariable, and from these constants the fundamental laws of matter have been derived.

Suppose a stick of sulfur held in the hand is rapidly twirled or thrown through the air. It may be shattered or broken but it still is sulfur; any change occurring is superficial and has to do only with shape or position. Suppose the sulfur is placed in a mortar and finely ground, then fine iron filings added, and the two intimately mixed until a gray colored powder is obtained. If the powder is fine enough, it is possible that the naked eye may not detect the different particles and that the mass will present a uniform and homogeneous appearance, but the mixture is not homogeneous. Should a portion of this mixture be placed beneath the lens of a microscope the particles of sulfur and iron readily can be distinguished from each other. The mixture is therefore heterogeneous; that is, composed of unlike or dissimilar particles and is simply a physical mixture resulting, as is said in chemistry, from **a physical change.** The proportion of either ingredient may be changed at will, either by adding more of one of the ingredients or by the removal of one of those present. By adding carbon disulfide the sulfur can be dissolved from the mixture and poured off, leaving the iron, or by applying a magnet the iron may be withdrawn. Suppose that a part of this mixture of powdered iron and sulfur is placed within a test tube and heated over a Bunsen burner; the mass will fuse, will reach a red heat, and finally will glow brilliantly, and when cooled will present the appearance of a black, hard, fused mass. If a fragment be broken off, powdered, and placed beneath the microscope it will be seen that it presents a homogeneous appearance, all particles being similar. An attempt to remove a portion of the particles with a magnet will fail, and any solvent used will act on all particles alike. Clearly the mass is different from the original powder because the heating of the sulfur and iron together has produced a **chemical change** in which a new substance or compound has been formed. This new compound is called ferrous sulfide and is composed of approximately 35 per cent of sulfur and 65 per cent of iron by weight. These weights are constant and never vary, as is the case in physical mixtures. From this fact the following law has been adduced: "*A chemical compound is always composed of the same ingredients in the same proportions by weight.*" This is known as Dalton's law of Constant Proportions. Another example of this law is shown in the heating of 1 part of alcohol with 2.09 parts of oxygen (a total of 3.09 parts) which gives 1.91 parts of carbon dioxide and 1.18 parts of water (again a total of 3.09 parts). Dalton also discovered the law of Multiple Proportions which is: *If two or more elements form more than one compound, and one is considered as a constant, the different weights of the elements that combine with the constant are simple multiples of each other.* In water the weights of hydrogen and oxygen are in a ratio of 1 to 8 but in hydrogen dioxide the ratio is 1 to 16. Likewise carbon monoxide is composed of 3 parts of carbon and 4 parts of oxygen while carbon dioxide consists of 3 parts of carbon and 8 parts of oxygen. The law of Reciprocal Proportions states that: *The proportions in which any two elements unite with a third are the same when they unite with each other, or simple multiples thereof.* For example: Carbon dioxide contains 12 parts of carbon combined with 32 parts of oxygen; in methane 12 parts of carbon are combined with 4 parts of hydrogen; if hydrogen and oxygen form a compound, in accordance with this law, they should combine in proportions of 4 to 32 or in simple multiples thereof as 1 to 8, as is found in water.

A law, as the word is used in science, is a statement summing up facts which actually have been found to be true after a large number of experiments have been performed carefully, accurately observed, and verified.

It has been shown by the foregoing that a chemical change differs from a physical one in that, while physical changes are superficial, the changes occurring during a chemical reaction are internal. The whole nature of the reacting substances undergoes a profound change, resulting in the formation of new substances markedly differing in characteristics and properties from those of the original substance or substances.

To discover what elements are in any substance and to learn what are the laws governing the actions of elements upon each other is the principal object of chemistry. The process by which the composition of substances is determined is known as *analysis,* and that by which substances are produced by combining elements, is known as *synthesis.*

SOME PHYSICAL PHENOMENA OF MATTER

In the introduction it was stated that the sciences of chemistry and physics are both concerned with the investigation of the properties of matter and are closely related. It is therefore evident that the study of chemistry must be supplemented by and include a knowledge of the physical properties of matter from the viewpoint of the science of physics. Accordingly there will next be given a brief discussion of some of the physical phenomena of matter which are essential to the study of chemistry.

Physics is *the science which treats of the phenomena associated with matter in general and of the laws governing those phenomena.* It is also known as Natural Philosophy and formerly included the sciences of chemistry, biology, astronomy, and geology which are now classed as individual sciences.

Characteristics and properties of matter.

Anything that has weight and occupies space (takes up room) is known as matter. In the science of physics the unit of matter is the molecule; in chemistry the unit is the atom. Matter exists in three states: *Solid,* when it has a definite volume and shape and does not require confinement; *liquid,* when it has a definite volume, requires confinement on sides and bottom, and takes the shape of the containing vessel; and *gaseous,* when it has neither definite volume nor shape and must be confined on all sides. Science has demonstrated that all matter is composed of about 92 elemental substances which cannot themselves be resolved or split up into two or more substances and cannot be produced from other substances. It follows, then, that matter which can be resolved into two or more elemental substances is compound matter; therefore matter composed of molecules made up of two or more elemental substances is termed a *compound.*

One of the first fundamental laws of both chemistry and physics that man discovered in his experiments with substances in Nature was the *indestructibility* of matter, which means that, regardless of what chemical or physical change may take place, matter can neither be destroyed nor called into existence. After a chemical or physical change has occurred there remains as much matter as there was previous to the change and if a substance is changed physically or chemically it still exists in another form, as has been shown in the examples of mixing sulfur and iron and of heating sulfur and iron. Another example is the burning of a piece of wood weighing 10 Gms. in a closed

vessel containing a definite weight of oxygen. After combustion has taken place it will be found that the weight of the resulting materials, including gases formed, will be 10 Gms. plus the amount of oxygen used from the vessel. This law concerning the indestructibility of matter is also known as the law of Conservation of Matter.

All matter has the property of *volume* which is designated by the terms length, breadth, and thickness.

Matter possesses mass and weight. The *mass* of a substance, which does not vary, is the measure of the quantity of matter the substance contains. *Weight* is the measure of the difference between the attraction of the earth and that of surrounding bodies for bodies on the surface of the earth. The weight of a body may vary according to the quantity of matter it contains and its distance from the earth's center.

Porosity is a property of matter that signifies that a certain amount of space exists between the molecules of a substance. This property is quite evident in the common sponge and exists in varying degrees in all matter.

Compressibility allows the volume of a body to be diminished by pressure. It is a proof of porosity and exists to a great degree in gases.

Elasticity is the property which allows a body to resist deformation and resume its original form or volume when the altering force ceases to act.

Solidity is the property wherein the relative position of the molecules of a substance is fixed and cannot be altered without the application of force.

Fluidity is the property wherein the relative position of the molecules of a substance is not fixed and they are capable of gliding over each other with comparative ease, the body assuming the form of the vessel in which it is placed.

Tenacity is the property of a substance by which it resists the total separation of its molecules.

Ductility is the property of a substance whereby its form may be changed by the action of traction or pressure.

Malleability is the property of a substance which permits it to be hammered or rolled into sheets.

Hardness is the resistance which substances offer to being scratched by other substances. This is only a relative property for an object which is hard in reference to one substance may be soft in reference to others.

Brittleness is the relative property of a substance which allows it to be broken when struck a sharp blow.

Transparency is that property of a substance which allows the passage of rays of light.

In studying chemistry the word "force" is often used in connection with the natural phenomena affecting the many chemical and physical changes taking place and described. For this reason the definition of the word and its attendant word, energy, is given here.

Force is the action of one body upon another, or is that which produces, changes, or stops motion. It is a manifestation of energy which may be caused in different ways, as by electricity, heat, and light.

Energy is a property possessed by all matter which may be defined as the capacity to do work and exists in one of two states, kinetic or potential. *Kinetic energy* is that state recognizable as heat, light, or motion. *Potential energy* is the latent power of all matter to produce a change, and is defined as the energy of position. A supported object has potential energy due to its position. When the support is withdrawn its potential energy is transformed into kinetic energy by the motion of the falling object. Kinetic energy is rep-

resentative of motion, visible in the movement of a mass, or evident in light and heat due to the invisible motion of molecules.

Just as matter can neither be created nor destroyed, neither can energy be created nor destroyed, and the total amount of energy in the universe remains constant and unchangeable. Energy that apparently is lost actually goes off in some other form of energy, most of it in heat. From a given amount of heat a relative amount of mechanical motion can be obtained, and vice versa. A similar relation exists between heat and electrical energy, and between these and chemical energy. By burning a definite amount of material a relative amount of heat is obtained; and by the application of this heat a corresponding amount of chemical action is produced. Although there is no direct way of proving that energy is never destroyed, all experimental evidence points to the principle that: *Energy is never created and never destroyed and all forms of energy are convertible, one into another, without loss, the total amount of energy in the universe remaining constant.* This principle is termed the law of the Conservation of Energy and is applied to atomic and molecular changes, to electrical phenomena, to biological phenomena, in fact, to all the processes of Nature.

Pressure.

Pressure is that force which tends to decrease the volume or alter the shape of a substance in direct proportion to the density or weight of the substance exerting the pressure. The density of a substance is measured by its *specific weight* which is represented by an abstract number showing the density of a given volume of substance as compared with that of water, hydrogen, or some other standard substance, both substances having the same temperature or the temperature of each being known. This is more commonly known as *specific gravity.* For example: 1 cc of sulfuric acid weighs 1.84 Gms; the weight of 1 cc of distilled water is 1 Gm; therefore, sulfuric acid is 1.84 times heavier than water. The equation used in determining specific weight (or gravity) is:

$$\text{Sp. Wt.} = \frac{W}{V};$$

W being the weight of a given substance and V being the weight of an equal volume of the substance used as the standard.

That gases are easily compressed is evident from the inflation of an automobile tire or a balloon. Even the atmosphere of the earth is under pressure, the air pressure at sea-level being 14.7 pounds per square inch (one atmosphere). This is due to the layers of the atmosphere exerting their weight upon the earth's surface, the pressure gradually decreasing with altitude. By doubling the pressure on a given quantity of gas in a tube its volume is decreased to ½; by trebling this pressure its volume is decreased to ⅓, etc. This principle is the basis of Boyle's law of the Compressibility of Gases: *The volume of any dry gas, the temperature remaining constant, varies inversely to the pressure applied.* The equation used in determining the volume of a gas is:

$$VP = V'P';$$

V being the original volume, P the original pressure, V′ the new volume and P′ the new pressure. *Problem.*—What will be the volume of 10 liters of gas, calculated at 14.7 pounds pressure, if it is subjected to a pressure of 29.4 pounds, the temperature remaining constant?

$$10 \times 14.7 = V' \times 29.4;$$
$$29.4V' = 147;$$
$$V' = 5 \text{ liters (new volume)}$$

Heat.

All matter is composed of very small particles called molecules, which are in constant motion. As the velocity of these molecules increases, the temperature of a body rises. A decrease in molecular velocity causes a corresponding decrease in temperature. Consequently heat may be defined as *kinetic energy due to molecular motion.* Heat is derived from many sources, the sun being the most important. Evidence that the interior of the earth is highly heated is furnished by molten rock issuing from volcanoes, and boiling water spouting from geysers. Chemical reactions are important sources of heat, especially those of oxidation. Mechanical action can be transformed into heat, friction being a common example.

The heat of an object and its temperature are different entities. It is possible for a body to have a high temperature and little heat; it may have a low temperature and little heat; it may have a high temperature and much heat; or it is possible for it to have a low temperature and a large quantity of heat. A burning match has a high temperature but gives off little heat, whereas a steam radiator has a comparatively low temperature but gives off much heat. Temperature is measured by degrees, heat by calories. The terms "hot", "cold" and "warm" are used to indicate temperature, but their use is only relative. Inasmuch as man's temperature sense is unreliable thermometers necessarily are used to measure temperature. Several scales are used on thermometers, the Centigrade and Fahrenheit being the most common; the former is employed in scientific measurements, the latter in weather observations and household applications. For the conversion of degrees of Centigrade temperature to Fahrenheit degrees and vice versa, *see* chapter on Pharmacy.

All substances expand to some degree when heated and contract when cooled. This phenomenon is most apparent in gases. Unlike liquids and solids, all gases have approximately the same coefficient of expansion. That all gases conduct themselves in practically the same manner under the influence of changes in temperature and pressure is explained by the assumption or hypothesis that *equal volumes of gases at the same temperature and pressure contain the same number of molecules.* This is known as Avogadro's Hypothesis. The coefficient of cubical expansion for gases is 1/273 of the volume at 0° C., or 0.00367 for each degree Centigrade. If a given volume of gas at 0° C. is cooled to a minus 100° C., it will be found that its volume has decreased 100/273, or, it has only 173/273 of its former volume. Theoretically, a gas cooled to a minus 273° C. would lose 273/273, or all of its volume. Actually it would be liquefied, then solidified. At zero volume, molecular motion having ceased, the body would be without heat, or absolutely cold. Consequently minus 273° C. is considered absolute zero, and from this factor the *absolute temperature* scale is calculated.

The uniform expansion of gases is defined by Charles' law: *If the pressure be constant, the volume of a given mass of dry gas is directly proportional to the absolute temperature.* This law may be expressed by the equation:

$$V : V' :: T : T';$$

V being the original volume, V′ the new volume, T the original temperature, and T′ the new temperature. The Centigrade temperature first must be converted into absolute temperature by adding 273 to the given Centigrade temperature. *Problem.*—What will be the volume of 117 cc of gas, calculated at 52.26° C., if the temperature is decreased to 5° C., the pressure remaining constant?

$$117 : V' :: (52.26+273) : (5+273);$$
$$117 : V' :: 325.26 : 278;$$
$$325.26V' = 32526;$$
$$V' = 100; \therefore \text{ new volume is 100 cc.}$$

To determine the volume of a gas subjected to changes in temperature and pressure the following formula is used:

$$\frac{VP}{T} = \frac{V'P'}{T'}$$

Problem.—What will be the volume of 500 cc of gas, calculated at 2° C. and a pressure of 10 pounds, if it is subjected to a pressure of 100 pounds at 35° C.?

$$\frac{500 \times 10}{2+273} = \frac{V' \times 100}{35+273};$$

$$\frac{5000}{275} = \frac{100V'}{308};$$

$$27500V' = 1540000;$$

$$V' = 56; \therefore \text{ new volume is 56 cc.}$$

Molecular physics.

It has been explained that all matter is made up of exceedingly small particles called molecules. In gases the distance between these molecules is relatively great, whereas in liquids the particles are closer together; but in all cases there is sufficient space between adjacent molecules to permit them to move freely. In solids this space is greatly diminished, proportional to the density of the substance.

The conception that molecules of all matter are in constant motion is known as the *kinetic theory.* (*See* chapter on Pharmacy). The velocity of this motion depends upon the nature of the substance, its state, and its temperature. Under a powerful microscope small particles suspended in a liquid can be seen moving backward and forward erratically or jumping up and down in ceaseless motion. These movements are caused by the motion of the liquid's molecules, which, by their impact on the particles drive them hither and thither. This motion, known as the Brownian movement, is a manifestation of molecular motion and was first noticed in 1827 by a Scottish botanist named Brown while examining suspensions of pollen grains in water under a microscope.

Evidence of this molecular motion is demonstrated by the diffusion and evaporation of matter. If a jar containing carbon dioxide is placed directly under one containing hydrogen, with their openings together, it will be found that the carbon dioxide will diffuse upward and mix with the hydrogen. As carbon dioxide is 22 times heavier than hydrogen, had it been placed above, its movement downward into the jar of hydrogen could be explained by its greater weight. The movement upward of the carbon dioxide, diffusing through the hydrogen, is therefore possible only because of the movement of the molecules. The diffusion of liquids through a semipermeable membrane, which is continuously occurring in living cells, is known as *osmosis* and is explained by this molecular motion. In the evaporation of water the molecules are constantly bounding upward; some mix with air currents and are carried away while others rebound off the air molecules back into the water. If the resistance of the air molecules is removed by vacuum, evaporation proceeds more rapidly. Some evaporation occurs from solids and is readily noted with substances like camphor, musk, and iodine crystals.

Because there is ceaseless molecular motion it is remarkable that all substances do not evaporate rapidly and expand indefinitely. Yet many solids have great tensile strength and enormous forces are required to pull them apart. Opposing molecular motion there is a strong force binding together the molecules. This force of attraction between like molecules is called *cohesion.* Unlike molecules may also *adhere* to one another strongly. The force of attraction between unlike molecules is called *adhesion.*

An examination of the surface of water in a container shows that it is not exactly level or plane, but slightly concave. The edge of the column in contact with the glass is raised above the general level, forming a crescent-shaped surface called the *meniscus.* The lifting of the water at the edge is caused by the adhesion of the water molecules to the glass, this attraction being greater than the cohesion between the water molecules. A line drawn through the bottom of the meniscus of transparent and the top of opaque liquids usually is selected as the reading point.

When a column of mercury is examined the edges are found to be depressed and the surface slightly convex, because in this condition cohesion between the molecules is greater than their adhesion to the glass.

If a finger is placed in thick molasses and withdrawn one is conscious that a certain amount of force is required to separate the molecules of the molasses. This demonstrates the cohesion of molecules.

Surface tension.—The surface of all liquids has a tendency to contract, which tendency is known as surface tension and is the result of action of the molecules of the liquid. In contracting the surface of the liquid tends to assume a spherical shape because a sphere is the geometrical figure in which a given volume has the least surface; in other words, surface tension tends to reduce the surface area of a liquid, or to make the surface area smaller.

A molecule in the interior of a liquid is attracted equally from all directions by the cohesion of the surrounding molecules, while those on the surface have only molecules of air above to attract them. As a result the attraction on the surface molecules is unbalanced and they are attracted only by the force tending to pull them out of the surface toward the interior of the liquid. This unbalanced attraction causes the surface to contract to as small an area as possible and it then acts like an elastic membrane.

Such a condition may be demonstrated by floating a clean needle on the surface of water. A careful examination shows that the needle floats in a hollow, the water behaving as though a thin elastic film or membrane had been stretched across its surface; the weight of the needle is not great enough to break through. A wet needle cannot be floated in this manner due to the cohesion of the water molecules; hence, the experiment is more easily performed if the needle is covered with oil.

Like water, all liquids have this property. On alcohol the film lacks the strength of that on water. Many oils possess a weaker film but have greater *viscosity;* that is, the resistance offered by a liquid to the relative motion of its particles causes more friction within the liquid itself and gives it a supportive surface.

Capillarity.—This property of liquids is due to the combined forces of adhesion and surface tension. The adhesion of water to the surrounding medium causes the surface of the water to become concave. Surface tension tends to decrease the surface area, or flatten it, by contraction. The two forces working together raise the liquid above the surrounding level. The height to which a liquid will be lifted depends upon its density and the strength of the liquid film.

The phenomenon of capillarity is governed by the following rules: 1. Liquids rise in capillary tubes if the liquids wet the tubes and are depressed if they do not; 2. The elevation or depression is inversely proportional to the diameter of the tube; and 3. The amount of elevation or depression decreases as the temperature increases.

Solution.—It is common knowledge that a piece of salt dissolves when it is placed in water. Water in this case is called the *solvent* and salt the *solute*, and the molecules of the solute occupy space between the molecules of the solvent. All solutions possess the following characteristic properties: 1. A solution is of the same nature throughout and each unit volume of the solvent contains the same amount of the solute; 2. The solute does not separate from the solvent upon standing unless the temperature changes or some of the solvent is lost by evaporation; 3. Only a definite weight of solute can be dissolved in a given volume of solvent at any given temperature, and when the solvent holds all it can of the solute at that temperature it is said to be *saturated;* 4. The solubility of a solid generally increases with a rise of temperature; and 5. The solubility of a solid varies with the nature of the substance and the solvent used, water being the greatest general solvent and alcohol perhaps second.

Crystallization.—When the saturated solution of a solid is cooled or evaporated, some of the solute separates from the solvent in the form of crystals. Crystallization may occur when a liquid changes from the liquid to the solid state. During crystallization the molecules of the solid arrange themselves in definite geometric figures. The types of the crystals depend upon the nature of the substance and the conditions under which crystallization occurs.

Solubility of Liquids.—It is possible to dissolve one liquid in another, and in such a case either liquid may be considered the solvent. Two liquids which are mutually soluble are said to be *miscible;* if they are insoluble they are said to be *immiscible.* If an oily liquid is shaken with water so that finely divided particles of oil remain suspended in the water the resulting product is called an emulsion.

Solubility of gases.—All gases are soluble to some extent in water. When water is heated, bubbles, consisting of air which was dissolved, rise through the liquid and are liberated; hence, an increase in temperature decreases a liquid's ability to dissolve gases. This ability is increased by pressure and is employed in the manufacture of carbonated beverages. The increase in a liquid's ability to dissolve gases under pressure is governed by Henry's law: *The volume of a gas that can be absorbed by a liquid is directly proportional to the pressure applied.*

INORGANIC CHEMISTRY

The elements.

The earth, the atmosphere, plants, animals, and everything with which man is surrounded are composed of certain elementary substances in more or less complex forms. These substances are termed elements and each has definite characteristics and properties, chemical and physical, which are governed by a set of constants or laws. Regardless of the way in which the elements combine or separate, they do so according to the same definite principles or laws, a number of which have been discussed.

The elements at present known to science are shown in the table on page 660 and the atomic weights given are the 1937 International Atomic Weights.

As explained in the introduction **elements** *are substances which cannot be resolved into or built up from anything simpler.* This definition takes into consideration only the ordinary types of chemical change and takes no cognizance of those changes in elements that occur when they are subjected to bom-

bardment by α-rays emitted by radioactive substances, an example of which is the breaking down of nitrogen into hydrogen and helium by such bombardment.

Notation.—The names of many elements are derived from Greek or Latin words that signify some distinguishing feature or peculiarity of the element; others are named after mythological personages or deities, minerals containing them, places where they were discovered; and some are named after planets in the solar system. The names of the more recently discovered elements usually end in "um" or "on".

TABLE OF THE ELEMENTS

Element	Symbol	Atomic Weights (O=16)	Atomic Number	Valence	Specific Gravity	
					Water	Air
Actinium	Ac	227.0	89			
Alabamium		219.0±	85	1		
Aluminum	Al	26.97	13	3	2.7	
Antimony (*Stibium*)	Sb	121.76	51	3, 5	6.7	
Argon	A	39.944	18	0		1.38
Arsenic	As	74.91	33	3, 5	5.7	
Barium	Ba	137.36	56	2	3.5	
Beryllium	Be	9.02	4	2	1.84	
Bismuth	Bi	209.00	83	3, 5	9.8	
Boron	B	10.82	5	3	2.0	
Bromine	Br	79.916	35	1	3.12	
Cadmium	Cd	112.41	48	2	8.6	
Calcium	Ca	40.08	20	2	1.55	
Carbon	C	12.01	6	2, 4	2.26	
Cerium	Ce	140.13	58	3, 4	6.92	
Cæsium	Cs	132.91	55	1		
Chlorine	Cl	35.457	17	1	2.49	
Chromium	Cr	52.01	24	2, 3, 6	7.1	
Cobalt	Co	58.94	27	2, 3	8.9	
Columbium	Cb	92.91	41	3, 5	12.7	
Copper (*Cuprum*)	Cu	63.57	29	1, 2	8.9	
Dysprosium	Dy	162.46	66	3		
Erbium	Er	167.64	68	3	4.77	
Europium	Eu	152.0	63	3		
Fluorine	F	19.0	9	1		1.31
Gadolinium	Gd	159.6	64	3	1.31	
Gallium	Ga	69.72	31	3	5.94	
Germanium	Ge	72.60	32	2, 4	5.47	
Gold (*Aurum*)	Au	197.2	79	1, 3	19.32	
Hafnium	Hf	178.6	72	4		
Helium	He	4.002	2	0		0.137
Holmium	Ho	163.5	67	3		
Hydrogen	H	1.0078	1	1		0.069
Illinium	Il	146.0	61	3		
Indium	In	114.76	49	3		7.12
Iodine	I	126.92	53	1	4.94	
Iridium	Ir	193.1	77	3, 4	22.42	
Iron (*Ferrum*)	Fe	55.84	26	2, 3	7.86	
Krypton	Kr	83.7	36	0		2.18
Lanthanum	La	138.92	57		6.155	
Lead (*Plumbum*)	Pb	207.21	82	2, 4	11.34	
Lithium	Li	6.94	3	1	0.534	
Lutecium	Lu	175.0	71	3		
Masurium	Ma	98.8	43			
Magnesium	Mg	24.32	12	2	1.74	
Manganese	Mn	54.93	25	2, 4, 6, 7	7.42	
Mercury (*Hydrargyrum*)	Hg	200.61	80	1, 2	13.59	
Molybdenum	Mo	96.0	42		9.01	
Neodymium	Nd	144.27	60	3	6.95	
Neon	Ne	20.183	10	0		0.674
Nickel	Ni	58.69	28	2, 3	8.75	
Nitrogen	N	14.008	7	3, 5		0.967
Osmium	Os	191.50	76	2, 3, 4, 8	22.48	
Oxygen	O	16.00	8	2		1.105
Palladium	Pd	106.70	46	2, 4	12.16	
Phosphorus	P	31.02	15	3, 5	1.83	
Platinum	Pt	195.23	78	2, 4	21.37	
Pollonium	Po	210.0	84	3, 5		
Potassium (*Kalium*)	K	39.096	19	1	0.870	
Praseodymium	Pr	140.92	59	3	6.48	
Protoactinium	Pa	231.0	91	3, 5		
Radium	Ra	226.05	88	2		
Radon	Rn	222.0	86	0		
Rhenium	Re	186.31	75	2, 4, 6, 7		
Rhodium	Rh	102.91	45	3	12.44	
Rubidium	Rb	85.48	37	1	1.52	

TABLE OF THE ELEMENTS—Continued

Element	Symbol	Atomic Weights (O=16)	Atomic Number	Valence	Specific Gravity	
					Water	Air
Ruthenium	Ru	101.7	44	3, 4, 6, 8	12.06	-------
Samarium	Sm	150.43	62	3	7.75	-------
Scandium	Sc	45.10	21	3	-------	-------
Selenium	Se	78.96	34	2, 4, 6	4.65	-------
Silicon	Si	28.06	14	4	2.42	-------
Silver (*Argentum*)	Ag	107.88	47	1	10.50	-------
Sodium (*Natrium*)	Na	22.997	11	1	0.971	-------
Strontium	Sr	87.63	38	2	2.54	-------
Sulfur	S	32.06	16	2, 4, 6	2.046	-------
Tantalum	Ta	180.88	73	5	16.6	-------
Tellurium	Te	127.61	52	4, 6	6.25	-------
Terbium	Tb	159.20	65	3	-------	-------
Thallium	Tl	204.39	81	1, 3	11.85	-------
Thorium	Th	232.12	90	4	11.2	-------
Thullium	Tm	169.40	69	3	-------	-------
Tin (*Stannum*)	Sn	118.70	50	2, 4	5.85	-------
Titanium	Ti	47.90	22	2, 4	4.5	-------
Tungsten	W	184.00	74	6	18.7	-------
Uranium	U	238.07	92	4, 6	18.68	-------
Vanadium	V	50.95	23	3, 5	5.69	-------
Virginium	Vi	225.0±	87	-------	-------	-------
Xenon	Xe	131.30	54	0	-------	4.42
Ytterbium	Yb	173.04	70	3	-------	-------
Yttrium	Y	88.92	39	3	3.80	-------
Zinc	Zn	65.38	30	2	7.00	-------
Zirconium	Zr	91.22	40	4	4.15	-------

For convenience and simplicity in expressing the composition of substances made up of various elements, in representing the results of chemical action, and in working out chemical equations, there is used an abbreviated form of chemical language or a system of *symbols*. These symbols are abbreviations of the names of the elements and have become fixed by long usage. They usually consist of the first letter of the names of the most important, most abundant or earliest-discovered elements, as O for oxygen, H for hydrogen, N for nitrogen, etc., and in cases where several elements have the same initial letter some other letter of the name is added, Ni for nickel, Ba for barium, Bi for bismuth, etc. In a few instances the symbol is derived from the old Latin name of an element, as Au for gold, Cu for copper, Fe for iron, Na for sodium, etc. As has been stated before, symbols refer to the atom of an element, and the number of atoms or molecules of an element in a substance is shown by placing numbers before or after the symbol. A symbol therefore represents not only the name of an element but a definite quantity of that element, an atom or a molecule, and as atoms and molecules have weight it also represents a definite weight of the element. A collection of symbols, with any attached numbers, shows how the atoms or molecules of an element are united in a substance, and such a collection is known as a *chemical formula.*

A chemical formula is a collection of symbols and numbers showing the kinds and amounts of elements contained in a substance, or compound. A formula standing alone represents one molecule of the substance. A symbol of an element contained in a molecule represents one atom of that element. If more than one atom is present in a molecule the proper small numeral is placed after and slightly below the symbol, and if more than one molecule is present a large numeral is placed before the symbol. Placing a large numeral before a symbol or before a collection of symbols multiplies everything following the numeral including the subscripted small numerals. For example: H_2O is the formula for water, and as so written represents one molecule of that compound, while $2H_2O$ represents two molecules consisting of four atoms of

hydrogen and two atoms of oxygen. To be correct the valences (*see* p. 664) in a chemical formula must balance. It has been stated that oxygen has a valence of II and that the valence of hydrogen is I. Manifestly one atom of hydrogen is not the equivalent of one atom of oxygen in combining power, and if the two are combined it will require two atoms of hydrogen to balance or equalize one atom of oxygen, because in any given compound all valences of each atom must be employed; that is to say, no element may have a free valence in any saturated compound. (*See* p. 665.) The valence of barium is II, and therefore one atom of barium can unite with one atom of oxygen to form a molecule of barium oxide. If the valence of one element of a compound is a multiple of the valence of the other element in the compound, take the symbol of the element with the lower valence as many times as it is contained in the valence of the other element and write the quotient as the exponent of the element with the lower valence as directed before. To write the formula of silicon oxide and have it balance, silicon having a valence of IV and oxygen II, the symbol of oxygen must be multiplied by 2. The formula of silicon oxide, therefore is SiO_2. If the valences of the two elements concerned are not equivalent and are not multiples of each other, write the symbols side by side and take each symbol as many times as the other has valences. The valence of aluminum is III, and one atom of that element is not balanced by one atom of oxygen with a valence of II, so to write the correct formula of aluminum oxide it is necessary to take the symbol of aluminum twice and the symbol of oxygen thrice, which gives the formula Al_2O_3. This is the simpliest arrangement in which the two can be combined to form a compound.

Chemical formulas are of four kinds, which are named and described as follows: *Empirical formulas* show the quality but not the quantity (other than relative) of compounds, as in $(C_6H_{10}O_5)_x$, the formula of starch, but when some special arrangement of the atoms of the substance is made to show not only the quality and quantity of the elements in the compound but the relationship between the different elements or groups of elements they are known as *rational formulas*, an example of such an arrangement being $(OH)_2SO_2$ the formula of sulfuric acid. *Graphic* or *structural formulas* are those in which the relative position of the atoms is shown as a picture, the exact linking of the atoms being given with the symbols of the elements entering into the compound. Graphic formulas are shown on pages 714 and 715. *Stereochemic* formulas are used in the study of such advanced chemistry that they will not be discussed here.

In order to understand the use of chemical formulas, especially graphic formulas, a knowledge of the combining power of elements, which is based on that of the atoms of the element, is necessary.

Atomic weight.—The symbols of the elements represent a quantitative portion of the substance they designate, and each symbol signifies the smallest division of that element present in a molecule, and denotes a definite and fixed quantity, as, for example, in the formula NaCl the symbol Na represents 22.997 parts of sodium and the symbol Cl represents 35.457 parts of chlorine as combined in a molecule of sodium chloride.

Atoms of the same element always possess the same weight in relation to any definite standard selected with which to compare them, but the weight of an atom of one element is never the same as that of an atom of any other element. Atomic weight is purely relative and, as it is impossible to weigh single atoms, it is determined by comparison with the weight of some element selected as a standard. For many years hydrogen, the lightest of all known elements, was used as the standard for atomic weights and its atomic weight arbitrarily was placed as 1, but hydrogen is very difficult to obtain

in a pure state and mistakes as to its actual weight frequently occurred. Each time an apparatus or process was developed which came a little nearer to obtaining pure hydrogen, and consequently nearer the determination of its true weight, a revision, entailing recalculations of the atomic weights of all other elements, became necessary. This caused much work and finally the use of hydrogen as a standard was discontinued and oxygen substituted. Under the old system the atomic weight of oxygen was 15.88 but in the new system was fixed at 16. Thus when it is stated that the atomic weight of sulfur is approximately 32, it is meant that the weight of an atom of sulfur bears the same relationship to the weight of an atom of oxygen as 32 bears to 16, and similarly, as the atomic weight of iron is approximately 56, the relationship between the atomic weights of iron and of oxygen is as 56 is to 16. The absolute weight of the atom of any element is unknown but definite relative weights have been determined, and upon them all quantitative chemical analysis depends.

Molecular weight.—The weight of a molecule is the sum of the weights of all atoms which compose it. A molecule of hydrochloric acid is composed of an atom of hydrogen and an atom of chlorine. The atomic weight of hydrogen being 1.008 and the atomic weight of chlorine 35.457, the molecular weight of hydrochloric acid is the sum of 1.008 and 35.457, or 36.465, and the relationship of the molecular weight of hydrochloric acid is to the atomic weight of oxygen as 36.465 is to 16.

The molecular weight of any substance expressed in grams is called the *gram-molecular weight,* or *mole;* thus, 18.016 Gm. is a mole of water and 32 Gm. a mole of oxygen. At a given temperature and pressure the gram-molecular, or *molar,* weight of a gas will, in accordance with Avogadro's hypothesis, occupy a constant volume which is called the *gram-molecular volume* or the *molar volume.* When the given temperature is 0° C. and the given pressure is 760 mm. the molar volume of a gas is 22.415 liters.

Atomic number.—This is a number that indicates the position of an element in the Periodic Table and represents the net positive electrical charge on the nucleus of an atom. It also represents and is equal to the number of planetary electrons outside the nucleus upon which depend the chief physical and chemical properties of the elements; therefore a knowledge of the atomic numbers of the elements is important.

The net, or excess, positive electrical charge on the nucleus of an atom is equal to the number of natural units of positive electrical charge (protons) in the nucleus of an atom minus the number of natural units of negative electrical charge (electrons) in the nucleus. As the helium atom has an atomic mass of 4 and as the atomic mass of an atom is approximately proportional to the number of protons in the atom, the nucleus of the helium atom is considered as containing 4 protons. There being twice as many protons as electrons in the nucleus of an atom it follows that there are but 2 electrons in the nucleus of the helium atom and therefore the net or excess positive electrical charge is 4 minus 2 or 2, which is the atomic number of the element helium, and also represents and is equal to the number of planetary electrons outside the nucleus. For the helium atom to be electrically neutral it must have an equal number of positive and negative electrical charges, and as but 2 of the 4 electrons necessary to neutralize or balance the 4 protons are in the nucleus, the other 2 electrons must be outside of the nucleus.

In most cases atomic numbers follow the order of the atomic mass of the elements. Each element has its own atomic number which determines its

place in the Periodic Table and all its properties except those depending on atomic weight.

Atomic numbers are determined by X-ray spectra according to the method devised by H. G. J. Moseley (1887–1915), a brilliant British physicist killed in the World War. He found that the X-rays emitted by different elements when bombarded by cathode rays in a vacuum tube give different X-ray spectra and hence the X-rays were of different wavelengths. By studying these characteristics he was able to calculate the number of the element giving off the X-rays, and his discovery made it possible to determine the number of elements, how many were missing, and to correct discrepancies in the position of certain elements in the Periodic Table as based on their atomic weights.

Valence.

This is the term used to describe the power of the atoms of elements to combine with the atoms of other elements. It sometimes is spoken of as the saturating or replacing power of elements and as chemical affinity. As stated in the introduction hydrogen is taken as the standard in fixing the valuation of valences, and its valence arbitrarily is designated as one. In some elements valence is comparative only, because they will not combine with hydrogen, as mercury, for instance. The valence of such elements is determined by comparison of the noncombining element with one which will combine with hydrogen. Therefore, as one atom of mercury will combine with one of oxygen, and it is known that one oxygen will combine with two hydrogen, the valence of mercury is said to be two. If an element has such combining power, or valence, that it can unite with two atoms of hydrogen, it is said to have a valence of two; if it can unite with four atoms of hydrogen its valence is four, etc. Elements which do not form compounds, such as the inert gases, are said to have no valence. Elements often are designated as univalent, divalent, trivalent, or tetravalent respectively when their atoms are possessed of one, two, three, or four valences. Similarly, they may be designated as monads, diads, triads, tetrads, etc. The valence of an element may be indicated also by Roman numerals placed slightly above and to the right of the symbol.

The table following, which is illustrative only, shows the difference in the number of hydrogen atoms which combine with one atom of several elements in the hydrogen compounds given, and indicates the valence of the element in the compound with which the hydrogen has combined.

Valence of I	Valence of II	Valence of III	Valence of IV
HCl	H_2O	H_3N	H_4C
HBr	H_2S	H_3P	H_4Si
HF	H_2Se	H_3As	
HI	H_2Te	H_3Sb	

Chlorine and bromine which combine with hydrogen, atom for atom, are monads. Oxygen and sulfur require two atoms of hydrogen for saturation and are therefore diads. Sodium does not combine with hydrogen, but as in its reaction with hydrogen chloride (HCl) it replaces hydrogen, atom for atom, its valence as a monad is established. Similarly, as an atom of zinc in its reaction with hydrogen chloride displaces two atoms of hydrogen, it is a diad. The valence of all the elements toward hydrogen is constant and unchangeable.

A hexad atom can unite with and completely neutralize six atoms of a monad, three atoms of a diad, two atoms of a triad, or one atom of a hexad. An atom of a tetrad could unite with four atoms of a monad, two atoms of a diad, or

one atom of another tetrad. Furthermore, any triad, tetrad, etc., atom may neutralize several different kinds of atoms of lower valence at one and the same time. For example, a hexad may unite with one triad, one diad, and one monad, or with any other combination of atoms the sum of whose valences does not exceed six.

Valence may be likened to men having as many hands as elements have valences and each hand ready to grasp the hand of another person and form a bond. Sometimes, as has been shown, one hand may be so strong that it takes more than one of the other's hands to hold the grip which forms the bond.

Certain elements may possess more than one valence and this condition is known as *polyvalence.* An atom of mercury, for example, under some circumstances will combine with one atom of chlorine, forming mercurous chloride, commonly known as calomel, and under other conditions it will combine with two atoms of that element to form mercuric chloride, popularly called bichloride of mercury. Just why an element may possess this quality of polyvalence is not known; it only is known that they do possess it.

When an element changes its valence, either higher or lower, the change usually is in degrees of two, changing from monad to triad, diad to tetrad. etc., or the reverse. Exceptions to this rule are known, however, as iron, which changes its valence 1 degree at a time, from a valence of 2 to a valence of 3, and mercury, which changes from 1 to 2.

That these varying valences may be indicated, the terminations *ous* and *ic* are used, denoting the lower and higher valence, respectively, as cupr*ous* oxide, Cu_2O, in which copper has the valence of 1, and cupr*ic* oxide, CuO, in which copper has the valence of 2.

When chlorine, bromine, and iodine combine with hydrogen they are always monads, as they also are when combined with metals, as copper chloride ($CuCl_2$) or bismuth chloride ($BiCl_3$). But when the various elements combine with the diad oxygen, or such elements as chlorine and bromine, variations in the valence of these elements develop. This valence toward oxygen or the halogens, is termed halogen valence, usually increases in increments of 2, and is an example of polyvalence. The variation of the oxygen, or halogen, valence of sulfur and osmium is shown in the table following.

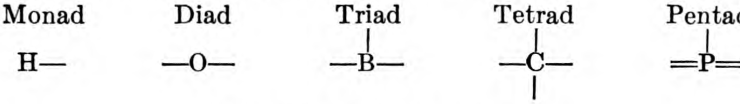
Valence of III	Valence of IV	Valence of VI	Valence of VII
S_2O_3	SO_2	SO_3	S_2O_7
Valence of II	Valence of IV	Valence of VIII	
OsO	OsO_2	OsO_4	

When all the valences, or bonds, of one element have been satisfied or replaced by a like number of another element, the resulting compound is said to be *saturated*, but where one of the elements of a group has a valence less than its maximum valence the group is said to be *unsaturated.* In some compounds it is believed that the valences for which there is no satisfying valence may hook up with each other, although this is not known positively. Groups of elements having unsatisfied valences are known as *radicals* (SO_4, NO_3 OH, etc.). During chemical change a radical behaves as a unit similar to an individual atom and has a definite valence and retains its structure throughout the reaction.

In ammonium chloride, NH_4Cl, it is known that nitrogen acts as a pentad and has all valences satisfied, while in ammonia gas, NH_3, it is known that nitrogen acts as a triad having 3 valences satisfied. The fact that when hydrochloric acid is added to ammonia gas, ammonium chloride is produced, with the consequent increase in valence from 3 to 5, and the knowledge of similar occurrences in other compounds, has led to the belief that possibly the unsatisfied valences unite with each other in compounds which otherwise would not be saturated.

Valence also is indicated by using the symbol of the element with bonds, or arms as they might be called, equal to the degrees of valence, extending from it. It is not necessary that these bonds be attached to the symbol in any definite position, but only that the proper number of bonds corresponding to the degree of valence be used. To illustrate this the following examples are given showing the placing of the required number of bonds about the symbol of the element and the name of the degree of valence:

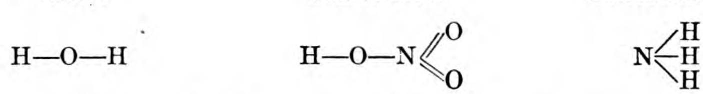
Monad Diad Triad Tetrad Pentad



Different positions of bonds

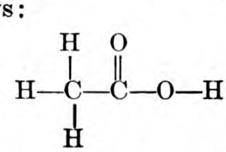
Practical use of graphic formulas to show the composition of compounds is obtained by linking the bonds of the symbol of one element with those of others, so that all bonds are joined, always remembering that one bond of an element can be linked with only one bond of another element. Some examples of common compounds written graphically are:

Water Nitric Acid Ammonia (gas)



To show how the formula of a compound may be written, acetic acid can be represented in any of the following ways:

CH_3COOH; $C_2H_4O_2$;



In writing the usual chemical equations none of the various ways of indicating valence is ordinarily used, and it must be remembered that under no circumstances do the bonds used in graphic or structural formulas actually exist; they are used only to indicate theoretically the relationship or linking together of the different atoms in compounds.

As stated in the introduction and in the discussion of atomic structure the valence of atoms is determined by the number of electrons contained in the outer shell or orbit. This is due to the gain or loss of electrons in this shell or orbit in order to complete its symmetry. Metallic elements lose electrons readily while nonmetallic elements readily gain them. Amphoteric or intermediate elements, which partake of the characteristics of both metals and nonmetals, have the ability to gain or lose electrons according to the influences by which they are surrounded.

Beryllium with an atomic weight of 9, has in its nucleus 9 protons and 5 electrons (fig. 150(*a*)). Surrounding the nucleus is one complete orbit or shell of two electrons and there are two valence electrons in the outer orbit. It becomes symmetrical by the loss of its two valence electrons, leaving it with an excess of two positive charges, forming a bivalent ion, Be^{++}. Therefore, it requires one atom of a diad or two atoms of a monad for saturation. Hence, beryllium readily combines with one atom of oxygen, which requires two electrons to complete its outer shell; or it might combine with two atoms of hydrogen, each hydrogen atom requiring one electron to complete its respective outer shell. Boron can lose three electrons, hence, it is trivalent (fig. 150 (*b*)). The carbon atom contains 4 valence electrons and will become symmetrical either by the addition or loss of 4 electrons (fig. 150 (*c*)). While the ion of carbon is unknown, the compounds formed by the carbon atom indicate its intermediate nature and demonstrate that its chemical behavior is governed by the same principles that control both the metals and nonmetals.

In the oxygen atom there are 6 electrons in the outer shell (fig. 150 (*d*)). If it were to resort to the symmetry of the helium atom it would be compelled to lose 6 electrons from its outer shell, but by gaining 2 electrons it assumes the symmetry of the neon atom (fig. 150 (*e*)). After gaining 2 electrons it has an excess of 2 negative charges, so it is said to have a valence of minus II. The outer shell of the fluorine atom assumes symmetry upon the addition of 1 electron, therefore its valence is minus I (fig. 150 (*f*)).

The electronic theory.

Electricity is spoken of as being *static* when it remains stationary, or at rest, and as *dynamic*, when it is in action, or in motion, and produces power, heat, and light. Static electricity may become active by friction.

It has long been known that when certain solids, as amber, rubber, glass, etc., which do not conduct electricity, are rubbed with a piece of wool, or silk, or fur, they acquire the ability to attract light objects such as small pieces of paper, cork, pith, feathers, etc. The solids are then said to have become electrified, or charged with electricity and practically every solid, when rubbed with a different substance, will acquire this property. They may also become electrified by liquids, as when liquids pass through pipes. The electrification in all cases is the result of friction activating the static form of electricity in the substances themselves.

If a rubber rod is electrified by rubbing with wool and then suspended by a thread and another electrified rubber rod is brought near to it, the two rods will *repel* each other, but if a glass rod that has been electrified by rubbing with silk is brought near to the suspended rubber rod, the two rods will *attract* each other. This is evidence that there is more than one state of electrification and is the basis for the law that *like electrifications repel and unlike attract*. To the electrification found on the glass rod the name *positive* has been given, and to that on the rubber rod the name *negative*.

When a body has become electrified it is said to be *charged* with electricity, or to have a *charge* of electricity, and the flowing of this charge from one body to another is termed a *current* of electricity. For a current of electricity to flow from one body to another it is necessary for the bodies to be connected by substances which will conduct, or carry, the current, and such substances are known as *conductors*, a familiar example being copper wire. Substances which will not conduct electricity are known as *nonconductors* or *insulators* and are used to support conducting substances and prevent them from losing their electrical charge, common examples being rubber and glass. Due to

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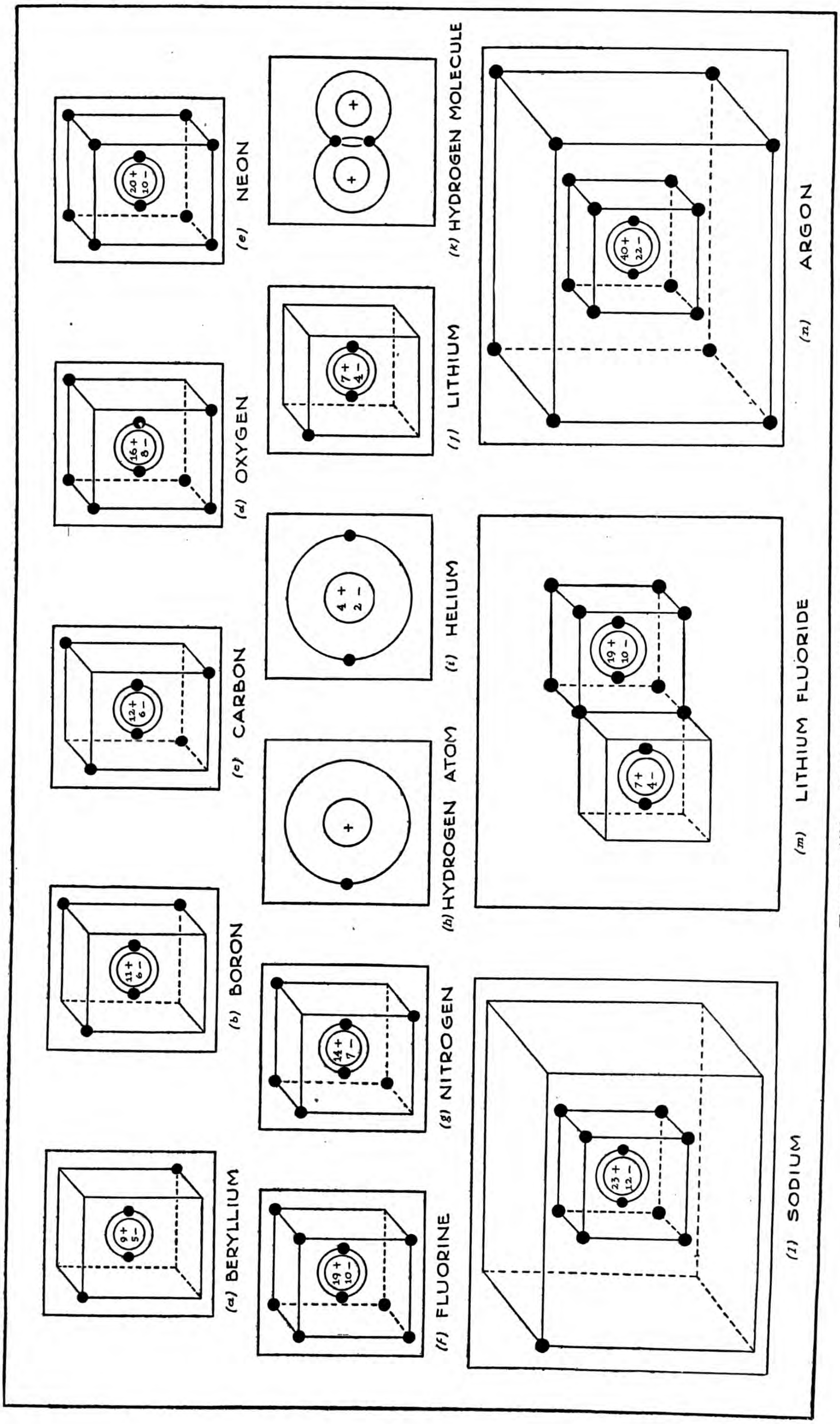


FIGURE 150.—Shells and orbits of elements.

the fact that in different substances the degree of conductivity varies it is not possible to classify them strictly as either conductors or nonconductors, and they are therefore spoken of as being good or poor conductors, metals being the best and glass, rubber, sealing wax, and like substances the poorest.

Many important facts concerning the relations between elements have been determined through knowledge gained by the practical application of the law that like electricities repel and unlike attract, and that bodies charged with positive or negative electricity act in the same manner.

It has been explained that all matter is considered as composed of electrons charged with negative electricity and of protons charged with positive electricity. This has been shown by experiments carried out on solutions of substances made up of known elements in water, contained in vessels called decomposing cells. In these cells are placed the positive and negative terminals, or electrodes, of an apparatus producing electricity, to which metallic plates are usually attached. If perfectly pure water, which is an extremely rare product, is then poured into the cell it will be found that no electricity will pass through it. If, however, a small amount of an acid, a base, or a salt be added to the water the solution will readily conduct the electric current. Substances which, when added to water, make it possible for the solution to conduct electricity are known as *electrolytes*, and substances which do not, as organic bodies like sugar, starch, and albumin, are known as *nonelectrolytes*. The substances used as electrolytes are electrically neutral or balanced, or, in other words, the protons and electrons in their atoms are equal in number.

An electric current in passing through a solution of an electrolyte brings about a chemical decomposition called *electrolysis* in which the electrolyte is separated or split up into two groups of particles, each of which flows either to the positive or negative electrodes and on contact becomes electrically neutral. If the water in a decomposing cell is made slightly acid it splits up into hydrogen gas and oxygen gas when the current passes through the solution, the hydrogen gas being liberated at the negative, or *cathode* electrode, and the oxygen gas at the positive, or *anode*, electrode. The liberation of hydrogen at the negative electrode shows that it was charged with positive electricity, and the liberation of oxygen at the positive electrode shows it was charged with negative electricity. Passage of an electric current through water in which copper sulfate has been dissolved causes copper to be deposited on the negative electrode and oxygen to be finally liberated at the positive electrode. Electrically charged particles of matter are called ions, from a Greek word meaning "to go", and ions charged with positive electricity are known as *cations*, because they go to the cathode, or negative, electrode, while those charged with negative electricity are known as *anions*, because they go to the anode, or positive, electrode. Cations and anions carry the matter with which they are associated, and on touching the electrodes the electric charges leave them and pass into the electrodes while the matter is deposited or liberated. In the electrolysis of hydrochloric acid in water (fig. 151) the acid ionizes into positive hydrogen cations and negative chlorine anions, with molecules of hydrogen gas and of chlorine gas being liberated later.

These examples have also shown that during electrolysis there is movement of the electrified particles of matter or ions in the solution toward the positive and negative electrodes in accordance with the law that unlike electricities attract. It is believed this movement is the result of the loss or gain by a neutral atom of an electrolyte of one or more electrons in the formation of the

particles of matter called ions. If electrons are lost the particle or ion becomes positively electrified, and if they are gained, the particle is negatively charged.

In the theory of *electrolytic dissociation*, or *ionization*, any one molecule of an electrolyte breaks down into one or more cations and one or more anions, the total number of the positive and negative charges being equal. Each cation and anion forms a nucleus to which may be attached a variable number of molecules of the solvent, and as a result, the moving particle or ion is complex.

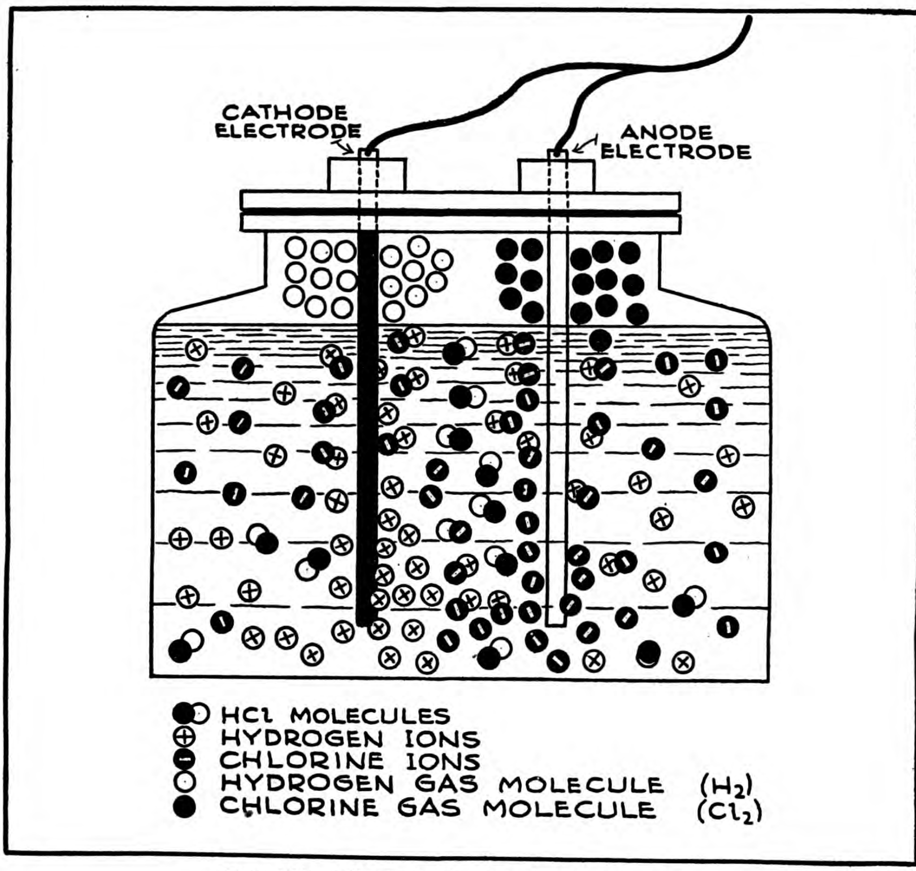


FIG. 151.—Electrolysis of hydrochloric acid.

The valence of the ion corresponds with the valence of the element or group of elements from which it is derived and is equal to the number of electric charges borne by it.

The process of electrolytic dissociation or ionization, or the formation of ions, may be represented as follows:

Hydrochloric acid	Hydrogen ion		Chlorine ion
$HCl \rightleftharpoons$	H^+	+	Cl^-
Sulfuric acid	2 Hydrogen ions		Sulfate ion
$H_2SO_4 \rightleftharpoons$	$2H^+$	+	SO_4^{--}

In the ionization of sulfuric acid positively charged hydrogen ions and negatively charged sulfate ions are formed by the dissociation of sulfuric acid molecules.

The arrows as used in the examples show that the reactions are reversible; that is, the products under suitable conditions will produce the original substances.

By electrolysis the positive hydrogen ions are attracted to the negative electrode where they lose their charges of positive electricity and are liberated as molecules of hydrogen gas. When the sulfate ions reach the positive electrode the process, while similar, is more complicated, but the liberation of oxygen is the final, or end, result.

Through the observation of these and similar phenomena the electronic theory has been developed, by which many chemical reactions have been made clear.

Numerous experiments have shown that the atoms of elements are composed of positive and negative electrically charged particles which are present in sufficient numbers to exactly balance or neutralize each other. The unit of positive electricity, the proton, is designated by placing a single plus sign above and to the right of the symbol of the element, while that of negative electricity, the electron, is designated by placing a single minus sign in the same position. As a result of experiments concerning the electrical properties of the atom certain postulates or assumptions have been laid down:

1. All atoms are composed of positive and negative electrical charges in equal quantities.

2. Each atom is composed of two main parts. The central part is called the nucleus; surrounding it at some distance are particles of negative electricity called electrons, considered to be arranged and rotating in concentric circles or orbits about the nucleus.

3. The nucleus consists of both positive and negative electricity, with positive charges always present in larger numbers than the negative.

4. The atomic number of an element signifies the number of extra protons present in its nucleus.

5. The external rotating or planetary electrons always exist in a sufficient number to balance the excess protons in the nucleus of the element (fig. 150 (*g*)).

The external electrons are associated in groups of shells, or orbits, the first shell or orbit being nearest the nucleus and complete, or symmetrical, when it is occupied by two electrons. The external electron of hydrogen is located in this shell (fig. 150 (*h*)), as are the two external electrons of helium (fig. 150 (*i*)). The lithium atom has 3 external electrons, so the third is contained in a second shell (fig. 150 (*j*)) outside of the first. The second shell is complete when it contains 8 electrons. Sodium which has 11 external electrons is demonstrated with its eleventh electron in a third shell (fig. 150 (*l*)) outside of the first two. The third shell, like the second, may be completed with 8 electrons; in heavier elements it contains 18. The fourth shell may contain 32 electrons. The evidence of the nature of these shells and the number of electrons they contain was obtained largely through a study of valence.

When an atom has in its outermost shell less than the number of electrons required for completeness, or symmetry, it always shows a tendency to combine with other atoms. For example: Lithium with an atomic number of three has only one electron in its outermost shell; fluorine with an atomic number of nine has seven. These two elements readily combine, the single electron of the lithium shell supplying the necessary electron to complete the outer shell of the fluorine atom, and producing the compound, lithium fluoride, which powerfully resists any effort to separate the two atoms (fig. 150 (*j*, *f*, & *m*)). When

an element is extremely active its atoms combine with each other forming molecules (fig. 150 (*k*)).

Atomic structure.—The hydrogen atom is the simplest of any of the elements and like all other atoms is electrically neutral, containing an equal number of electrons and protons. It readily loses one electron forming an ion which contains an excess of one proton and is represented by H^+. This electron, situated outside the nucleus and intimately connected with the chemical behavior of the atom, is termed the valence electron. All atoms possess valence electrons with the exception of the inert gases, helium, neon, argon, etc. (fig. 150 (*i, e, & n*)) and the basis of chemical activity is the interchange of the valence electrons among the elements to produce various compounds. The activity of these electrons is demonstrated when a substance is dissolved in water and the various atoms receive and contribute their outer electrons, according to their nature, to form ions. An atom that contributes, or loses, its electrons is left with an excess of protons, and hence is a positive ion or cation. A negative ion is formed when an atom receives, or gains, electrons, and as an excess of electrons is then present in its structure it is a negative ion or anion. In this form the individual atoms are electrically unbalanced. Upon removal of the solvent the ions revert to their original molecular structure.

In the study of the structure of atoms, the atomic numbers assigned to the various atoms are indicative of the number of excess protons contained in the nucleus, which excess in every case corresponds to the number of planetary electrons in the various shells surrounding the nucleus. To clarify the study of atomic structure it is necessary to consider the relative weights of the atoms (atomic weights) as whole numbers, and in most cases the atomic weights are so nearly whole numbers that the fraction of error is negligible. Also, it will be found that the approximate atomic weights represent the total number of protons or the total positive electrically charged units contained in the nucleus of the element considered. *Therefore:* Atomic numbers designate both the number of protons, or positive factors, in excess and the number of electrons contained in the electronic shells of a given atom; and the approximate atomic weights correspond to the total number of protons in a given atomic nucleus.

The atomic number of helium is 2 which denotes an excess of 2 protons which are balanced by 2 planetary electrons. The nucleus with its surrounding electrons forms a stable configuration in that the external shell is complete, there being no valence electrons present to combine it with other atoms. This is true, in fact, for helium, being an inert gas, is incapable of combining with other elements. This condition is indicative of a valence of zero.

Lithium, with an atomic weight of approximately 7 and an atomic number of 3 must contain 7 protons and 4 electrons in its nucleus and 3 rotating or planetary electrons in its electronic shells. Two of the planetary electrons are firmly held in the first shell, as are the two outer electrons in the helium atom. The remaining electron in the second shell produces an asymmetrical arrangement, in that the second shell requires 8 electrons for completion. This disturbs the forces within the atom. Theoretically, to overcome this asymmetry the valence electron is removed, forming a lithium ion (Li^+). This is true because the lithium atom is very active chemically, having a valence of one.

It is convenient to represent atoms containing more than one shell or orbit as cubes, as shown in figure 150, or as a series of concentric circles around the nucleus, but it must be remembered that such figures merely represent the postulated relationship of the various parts of the atom, do not imply that atoms are necessarily cubical or spherical in form, and that the electrons are not stationary but revolve about the nucleus.

Reactions and equations.

In chemistry these terms are synonymous in so far as their use is concerned. It has been shown how chemical symbols are used to indicate the composition of a substance, and chemical symbols are used further to show exactly the nature of the chemical changes which occur when different substances come in contact with each other. The grouping of the symbols in this manner is called a *reaction*, but, strictly speaking, the statement is an "equation of the reaction," as it is written in the form of an equation and both sides of the equation must balance. It is customary to speak of these expressions either as reactions or equations. The signs of addition, $+$, and equality, $=$ or $\rightarrow$, are used in expressing the reaction, but as the reaction may be reversible the use of the words "results in," "produces", or "gives" is preferred to "equals", and use of the arrow to the sign of equality. When an arrow is pointed upward ($\uparrow$) it indicates that a gas is liberated and when pointed downward ($\downarrow$) that a substance has been precipitated or thrown out of solution.

The use of chemical symbols to express a chemical equation may be described as a shorthand method of recording what has happened in a chemical reaction and obviously must be a statement of facts that actually occurred. In other words, the equation is written to fit the reaction, and consequently equations cannot be written until it is known through testing and experimenting exactly what has happened in any given instance. The general laws of chemistry and physics and observations of large numbers of reactions have been studied until it is known just what will happen in the majority of cases where specific reagents (compounds used for producing reactions) are brought in contact.

In writing reactions or equations, three difficulties usually are encountered. These difficulties are to know if a given change will occur, to know the amount of the substance to be used, and to know the character of the substance formed in the reaction. The first difficulty is experienced because the varying electrical natures of the elements affect their affinities, and because of the disturbing of ordinary affinities by the formation of insoluble bodies when liquid substances capable of producing them are brought together, the facility with which bodies that can be volatilized or converted into a gas diminish in their chemical power when this occurs, and in the proportion or concentration of the substances brought in contact with each other. The second difficulty is caused by the necessity of knowing the ratio in which the substances can react upon each other, which is determined by their valences. The third difficulty encountered is due to the electrical relations of the ions of the substances coming in contact with each other, in which it is necessary to remember that electro-positive ions can unite only with electro-negative ions.

Reactions are chemical changes in substances and changes in matter of this character affect the molecules of the substances involved therein. Molecules are the smallest portions of a chemical compound that retain the properties of that compound and are composed of two or more atoms which are, in turn, the smallest possible divisions of the elementary substances. The atoms composing the original molecules dissociate, or combine with like and unlike atoms of other molecules, to form new substances possessing entirely different properties from the original. For example: If an electric current is allowed to act upon water the water loses its identity as such and is resolved into two gases, hydrogen and oxygen. These products no longer possess the characteristics of water. In the rusting of iron, due to its combination with the oxygen of moist air, a reddish-brown powder is formed, iron oxide, which no longer has the characteristics of either iron or oxygen.

The attraction of one atom for another permits the formation of a compound. This attractive force is known as chemical affinity and varies greatly, not only among the various elements, but also with each element itself by the action of varying physical forces. The first condition necessary to produce a chemical change is intimate contact and freedom of motion between molecules, so that they may exchange their atoms. With solids this condition is obtained by dissolving them in a liquid medium. Some chemical reactions take place upon molecular contact while others need the application of physical forces such as heat, light, or electricity, along with molecular contact, to produce the desired change.

The most common types of reactions or chemical changes are:

1. *Synthetic reactions*, or direct combination, in which simple compounds or elements unite to form complex substances, as: $SO_3+H_2O \rightarrow H_2SO_4$;

2. *Analytical reactions*, or decomposition, which embrace a large variety of reactions whereby the elements are separated from their compounds for the purpose of forming insoluble bodies or stable substances capable of being identified and weighed, as: $BaCl_2+Na_2SO_4 \rightarrow BaSO_4+2NaCl$, in which reaction the barium sulfate is precipitated and therefore, the amount of it or of the sodium chloride may be determined;

3. *Substitution*, or displacement, wherein one element of a compound is displaced by another element, as: $Fe+2HCl \rightarrow FeCl_2+H_2$;

4. *Double decomposition*, or metathesis, is the most common type and is the mutual reaction of substances in solution to form new compounds by the interchange of atoms or atomic groups (radicals), as: $H_2SO_4+2NaCl \rightarrow NaSO_4+2HCl$; and

5. *Dissociation*, or reversible reactions which are those produced by physical forces such as heat, light and solution. The molecules of certain compounds separate into simpler forms which exist as long as the favoring conditions continue. When these conditions cease to act, the products of dissociation recombine to form the original substance:

$$HCl+\text{water} \leftrightarrows H^{+}+Cl^{-}$$

$$NH_4Cl+\text{heat} \leftrightarrows NH_3+HCl$$

It has been previously stated that under suitable conditions the products of reactions will produce the original substances and that such reactions are known as *reversible reactions*. This means that, to a certain extent, a reaction and its degree of completion may be controlled partially and in some cases made to proceed in either direction. Such reactions are also known as incomplete.

The reaction between calcium oxide and carbon dioxide is of this nature, for, if a stream of carbon dioxide is allowed to pass over calcium oxide, calcium carbonate is produced; while if calcium carbonate is heated, that compound is decomposed into calcium oxide and carbon dioxide. Such a reaction is written as follows:

$$CaCO_3+\text{heat} \rightleftarrows CaO+CO_2$$

This equation simply means that the reaction may proceed from left to right, or vice versa, according to the conditions obtaining at the time.

Equations.—A chemical equation expresses several important laws, among which are those of the Conservation of Matter and of Definite Proportions, indicates the weights of the reacting substances and their resulting products, and must balance and conform to the laws which govern it. In writing the chemical formula for potassium chlorate and its reaction due to the application of heat, experimental facts show that oxygen is liberated and the potassium chlorate converted into potassium chloride. It might be thought that

the equation $KClO_3 + heat \longrightarrow O_2 + KCl$ would express the reaction but examination shows that it is incorrect, in that while there are 3 atoms of oxygen on one side of the equation there are only 2 on the other, and the equation therefore fails to conform to the law of Conservation of Matter. To correct this the equation must be balanced by placing numbers, as necessary, before each of the chemical formulas, so that finally there will be the same number of atoms of each element on each side of the equation. These numbers show the smallest amount of the elements that can enter into the reaction, and must be whole numbers as it is obvious that half an atom cannot be used.

In the foregoing equation the oxygen molecule contains 2 atoms of O, but the formula for $KClO_3$ contains 3, and the O_3 and O_2 do not balance. Therefore, some multiple of 3 and 2 must be represented in the equation. As the smallest multiple of 3 and 2 is 6; enough $KClO_3$ must be used to furnish 6 atoms of O, and as $6 \div 3 = 2$, that number of parts of $KClO_3$ is required. The correct equation then will read: $2KClO_3 + heat \rightarrow 3O_2 + 2KCl$.

In stating equations it is necessary to remember that the molecular formulas of elements entering into combinations to form new compounds must always be used. Especially is this true of the gaseous elements such as hydrogen, oxygen, chlorine, nitrogen, etc., which can exist only in the free or molecular state. All but 11 of the elements have one atom to the molecule, the exceptions being arsenic, phosphorus, sulfur, selenium, bromine, iodine, fluorine, chlorine, hydrogen, oxygen, and nitrogen. Therefore when these elements are used in equations they must appear as As_4; P_4; S_8, S_6, S_2, or S; Se_8; Br_2; I_2; F_2; Cl_2; H_2; O_2; and N_2.

When dealing with reactions generally between acids and metals, or metallic oxides or hydroxides, it is safe to assume that a salt of known content will be formed; for example, when zinc is placed in a solution of hydrochloric acid it is known that zinc chloride will be among the products formed and that hydrogen will be another product.

In connection with the writing of equations showing reactions, the following rules, with examples, are given to assist the student.

1. Any metal plus any acid gives a salt of the metal plus hydrogen. Example:

$$\underset{\text{Metal}}{2Ag} + \underset{\text{Acid}}{2HCl} \rightarrow \underset{\text{Salt}}{2AgCl} + \underset{\text{Hydrogen}}{H_2}$$

2. Any hydroxide plus any acid gives a salt of the acid used plus water. Example:

$$\underset{\text{Hydroxide}}{NaOH} + \underset{\text{Acid}}{H_2SO_4} \rightarrow \underset{\text{Salt}}{NaHSO_4} + \underset{\text{Water}}{H_2O}$$

3. Any carbonate plus any acid gives a salt of the acid used plus carbon dioxide plus water. Example:

$$\underset{\text{Carbonate}}{Na_2CO_3} + \underset{\text{Acid}}{2HNO_3} \rightarrow \underset{\text{Salt}}{2NaNO_3} + \underset{\substack{\text{Carbon}\\ \text{Dioxide}}}{CO_2} + \underset{\text{Water}}{H_2O}$$

4. Any metal plus water which produces a reaction gives a hydroxide of the metal plus hydrogen. Example:

$$\underset{\text{Metal}}{2Na} + \underset{\text{Water}}{2H_2O} \rightarrow \underset{\text{Hydroxide}}{2NaOH} + \underset{\text{Hydrogen}}{H_2}$$

By the use of equations in conjunction with certain mathematical procedures it is possible to ascertain the percentage of each element entering into the composition of chemical compounds, the quantities of substances involved in

chemical reactions, the combining weights of elements, etc. The procedures necessary to obtain such information are spoken of as chemical arithmetic or *stoichiometry.*

Stoichiometry is that branch of chemistry which treats of the relations between the properties of substances and their composition, and of the methods of calculating the quantities of substances, by weight or volume, involved in chemical reactions. It is based on the fundamental laws of chemistry.

Chemical formulas and equations are made up of chemical symbols which represent atoms of elements and, as previously explained, definite weights of matter. The figures representing these weights are used in the mathematical calculations of stoichiometry, as shown in the examples appearing hereafter, in which also are explained the methods used in such calculations.

If 1 atom of zinc and 2 molecules of hydrochloric acid will produce 1 molecule of zinc chloride and 1 of hydrogen it follows, then, that a definite weight of each of the former must produce a definite weight of each of the latter, because, through the law of Conservation of Matter, no matter, or weight, can be lost or gained in any chemical reaction. The actual weight of no atom is known but the relative weights are and it is those which are used in chemical equations. After writing the symbols of the elements involved in this reaction in the form of an equation, figures representing the atomic and molecular weights of the elements and compounds are placed in the proper position just above the symbols in the equation and the result observed. Zinc has an atomic weight of approximately 65.4, and as only one atom of that element is involved in this equation that figure is placed above the symbol of zinc. The atomic weight of hydrogen is, roughly, 1, and of chlorine 35.5. The molecular weight of hydrochloric acid therefore is 36.5, but as that figure represents the weight of only one molecule and in this equation two molecules are necessary, the number is doubled and the number 73 placed above the formula of hydrochloric acid. The molecular weight of zinc chloride must be the atomic weight of zinc (65.4) plus twice the atomic weight of chlorine ($35.5 \times 2 = 71$) or 136.4, which is written above the formula of that compound, and 2, of course, is the molecular weight of hydrogen. The equation then appears as follows:

$$\overset{65.4}{Zn} + \overset{73}{2HCl} \rightarrow \overset{136.4}{ZnCl_2} + \overset{2}{H_2}.$$

As no weight may be lost or gained in a chemical reaction, the combined weights of zinc and hydrochloric acid should just equal the combined weights of zinc chloride and two atoms of hydrogen, and it is found that they do, the sum of the weights of the elements and compounds on either side of the equality sign being 138.4. Now, irrespective of what the actual weight of the atoms or molecules may be, this equation shows that 65.4 parts by weight of zinc and 73 parts by weight of hydrochloric acid will produce 136.4 parts by weight of zinc chloride and 2 parts by weight of hydrogen. One may substitute any unit of weight desired—grains, ounces, tons, kilograms, or grams—for the word "part" and the actual weights involved read off as such. If a chemical equation is written correctly, the combined weights of the reacting substances will exactly equal the combined weights of all the products. It naturally follows that if a compound is formed which contains more atoms of an element, or requires two or more radicals to balance it, and those amounts are not contained in one molecule of the substance from which it is to be supplied, more molecules of that substance must be used, as previously explained. In other words, enough of the substance must be used to supply the amounts

needed. Suppose metallic calcium is dropped into some hydrochloric acid. It is known that calcium chloride ($CaCl_2$) will be formed, the equation being:

$$\overset{40}{Ca} + \overset{73}{2HCl} \rightarrow \overset{111}{CaCl_2} + \overset{2}{H_2}$$

As a molecule of calcium chloride contains two atoms of chlorine and one molecule of hydrochloric acid contains only one atom of chlorine, it is necessary to use two molecules of that acid. Determining the weights involved in the equation, shows that 111 parts of calcium chloride and 2 parts of hydrogen are formed by the action of 73 parts of hydrochloric acid on 40 parts of calcium, all parts being by weight.

By applying these principles the weights of any substances required to produce a definite weight of a specific compound may be calculated. First the equation must be stated and balanced, next the reacting weights must be written in their respective places above the equation, and then, by making a simple statement in proportion, the required weights easily are ascertained.

Suppose the problem is to ascertain the quantity of hydrochloric acid necessary to produce 75 grams of calcium chloride. By reference to the preceding equation it is noted that 73 grams of hydrochloric acid will produce 111 grams of calcium chloride. It follows, then, that:

$$73 : 111 :: x : 75$$

wherein it is found that x equals 49.32+ grams of hydrochloric acid. Similarly, had the problem been to determine how much calcium chloride could be made from 1,850 grams of hydrochloric acid the statement would have been:

$$73 : 111 :: 1850 : x$$

and x would equal 2,813+ grams of calcium chloride.

The next examples given show a different method of working the problems occurring in chemical equations although based on the same principles as the others.

Suppose it is desired to make 20 Gms. of oxygen (O) without wasting material. Set down the formula and write the amount, in grams, above the substance to be obtained. Place an "x" to represent the unknown quantity above the substance to be weighed. Below the formulas write the formula weights, which are calculated from the atomic weights. The number before the formula is used as a multiplier to obtain the equation weight. The numbers for KCl are omitted as they do not enter into the problem.

$$
\begin{array}{lcccc}
 & x & & 20 & \\
 & 2KClO_3 & \rightarrow & 3O_2 & +2KCl \\
\text{Atomic weights:} & \overbrace{K,\ (39);\ Cl,\ (35.5);\ O,\ (16 \times 3)} & & \overbrace{O,\ (16 \times 2)} & \\
\text{Formula weights:} & 122.5 & & 32. & \\
\text{Equation weights:} & 2 \times 122.5 = 245. & & 3 \times 32 = 96. &
\end{array}
$$

if 245 grams of $KClO_3$ produce 96 grams of O, then:

$$245 : 96 :: x : 20$$
$$96x = 4900$$
$$x = 51,$$ the number of grams of $KClO_3$ required to produce 20 grams of O.

The "x" can be on either side of the arrow. In other words the weight of any product can be calculated, if the weight of any one of the substances is known.

The "x" and the known weight can also be used on the same side of the equation. What weight of hydrogen is required to react with 100 Gms. of iron oxide?

$$\begin{array}{lccc}
 & 100 & & x \\
 & Fe_2O_3 & + & 3H_2 \\
\text{Atomic weights:} & \overbrace{Fe,\ \underbrace{(56\times 2)}\,;O,\ \underbrace{(16\times 3)}} & & \overbrace{\underbrace{H,(1\times 2)}} \\
\text{Formula weights:} & \underbrace{112 \qquad\qquad 48} & & \underbrace{3\times 2} \\
\text{Equation weights:} & 160 & & 6
\end{array}$$

If 6 grams of hydrogen are required to react with 160 grams of iron oxide, then:

$$160 : 6 :: 100 : x$$
$$160x = 600$$
$$x = 3.75,$$ the number of grams of hydrogen required to react with 100 grams of iron oxide.

The weights expressed in the foregoing equations are for 100 per cent, or absolute compounds, which are compounds with absolutely no diluent or impurities present. Unfortunately such compounds rarely are met with in practice, so that when dealing with actual cases it generally is necessary, after determining the required weights of the absolute substance, to calculate how much of the impure or diluted product at hand will be necessary to furnish the required amount of absolute substance. In dealing with liquids the specific gravity, in addition, must be taken into consideration. Suppose the problem is to determine how many cc of a solution of sulfuric acid, specific gravity 1.90, 90 per cent by weight, will be required to liberate 1,125 Gms. of hydrochloric acid from the appropriate quantity of sodium chloride. The equation is written and the reacting weights calculated. Using approximate atomic weights, this would be as follows:

$$\underset{2NaCl}{117} + \underset{H_2SO_4}{98} \rightarrow \underset{Na_2SO_4}{142} + \underset{2HCl}{73}$$

which shows that 98 grams of absolute sulfuric acid will produce 73 grams of absolute hydrochloric acid. Then,

$$98 : 73 :: x : 1125$$

and x is found to equal 1,510+ Gms.

Now, the specific gravity of the solution of sulfuric acid to be used is 1.90, therefore 1 cc will weigh 1.9 Gms. (volume × sp. gr.=weight), of which 90 per cent, or 1.71 Gms., is absolute sulfuric acid. Then, if 1 cc contains 1.71 Gms. of absolute acid and 1,510 Gms. of the absolute acid are needed, by dividing 1,510 by 1.71 the required number of cc is ascertained, which is, in this case, 883+.

It also will be observed that many compounds are crystalline in character, and in these crystals the compounds are combined loosely with one or more molecules of water (water of crystallization), and the weight of this water, though it may be driven off by heating the crystal, must be taken into consideration when the crystals themselves are used. The molecular weight of sodium carbonate, for instance, is, in round numbers, 106, but crystals of this compound cannot be indicated always as Na_2CO_3. In one official salt the compound exists as $Na_2CO_3.10H_2O$; therefore to obtain 106 Gms. of the absolute salt in this case it will be necessary to weigh out 286 Gms. of the crystals of that compound.

Nomenclature and classification of chemical compounds.

To be a compound a substance must be composed of atoms of two or more elements which have combined to form molecules or the smallest particles of the substance. Simple molecules (H_2, P_4) consist of like atoms while compound molecules (H_2O, KI) are made up of unlike atoms.

The naming of chemical compounds depends on a system in which certain accepted terminations are added to the name of one of the elements in the compound. These terminations are considered as meaning that nothing but the elements specifically named is present in the compound. For compounds containing only two elements or one element and a radical the termination *ide* is used; compounds formed in the union of oxygen, sulfur, chlorine, etc., with another element or radical are known as ox*ides*, sulf*ides*, chlor*ides*, etc., respectively.

In addition to this termination there are other ways of distinguishing compounds, each of which indicates a compound formed by the combination of elements in different proportions. Copper oxide is the proper designation of both the cuprous and cupric salts of copper, for they contain only two elements, but they are different bodies. Therefore the cuprous salt is designated as copper *sub*oxide and the cupric salt as copper *mon*oxide. *Sub* is used to indicate a difference in the normal combination of the elements in a salt and in this case there is less oxygen in combination with copper than there is in copper monoxide. *Mon* is but one of the several syllables used to designate the relative quantities of elements which combine in more than one proportion, the others, with examples, being: Carbon *di*oxide, CO_2; sulfur *tri*oxide, SO_3; carbon *tetra*chloride, CCl_4; and phosphorus *penta*chloride, PCl_5, etc. Occasionally a compound has one-half more of an element than another compound containing the same elements, or the proportion is as 1 to 1½. But as fractions are not allowed in formulas the whole expression is multiplied by two and the proportion becomes as 2 to 3, and such compounds are known as *sesqui*-compounds, the word *sesqui* meaning one and a half. The formula of iron-sesquioxide, therefore, instead of being $FeO_{1\frac{1}{2}}$ is Fe_2O_3.

Other syllables and terminations used in the naming of compounds will be explained during consideration of acids, bases, and salts (these being the principal representatives of ternary compounds), those which have been given here being used almost entirely in binary compounds.

Binary compounds are compounds containing atoms of two elements, as water, H_2O, potassium iodide, KI, or calcium oxide, CaO. Compounds containing atoms of three or more different elements are known as *ternary compounds*, as potassium chlorate, $KClO_3$, magnesium sulfate, $MgSO_4$, or sulfuric acid, H_2SO_4.

Ternary compounds are considered as being first derived from binary compounds and the negative part of the formula of ternary compounds usually consists of a group of atoms which act in the same manner as the negative element in a binary compound. Thus, in the compounds sulfuric acid, H_2SO_4, and magnesium sulfate, $MgSO_4$, the hydrogen and magnesium are the metallic or positive parts, and the group SO_4 acts as the nonmetallic or negative part of the formula. Such groups of elements are termed *radicals* and will next be discussed.

Radicals are groups or combinations of the atoms of elements that play the part of a single atom in certain types of compounds. They appear in many compounds and although the groups remain intact and act as single atoms in chemical reactions they cannot exist in a free state but are always found in

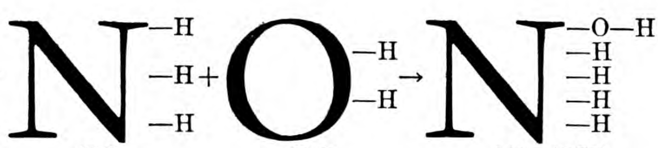
combination with other atoms. One radical, NH_4, or ammonium, acts as a positive metal. As explained under valence they are groups of atoms having unsatisfied valence. The valence of radicals is determined by the number of valencies unsatisfied, and is known as saturated, (CH_4), monad, (CH_3), diad, (CO), etc. With but few exceptions the names of radicals terminate in *yl*, as hydrox*yl*, carbon*yl*, meth*yl*, etc., and they are identified in chemical formulas by enclosing them in brackets or parentheses, as ($Fe(OH)_3$, instead of FeO_3H_3. In addition to being known as a radical such a group of atoms may be known as a residue; that is, what remains after the removal of an atom from a saturated molecule.

The formulas, valences, and names of some of the more important radicals are given in the table following.

Formula	Name	Valence	Formula	Name	Valence
NH_4	Ammonium	Monad.	CH_3	Methyl	Monad.
NO_3	Nitrate	Monad.	CN	Cyanogen	Monad.
OH	Hydroxyl	Monad.	CO	Carbonyl	Diad.

Although sometimes referred to as radicals, the groups SO_3 and SO_2 are really anhydrides, which are compounds derived from acids by the abstraction of a molecule of water. Literally, anhydride means "without water."

The positive radical ammonium, —NH_4, cannot exist by itself. When ammonia gas, NH_3, is dissolved in water a molecule of it and a molecule of water unite to form ammonium hydroxide, NH_4OH. Chemically, ammonia is nitrogen trihydride, and as such the nitrogen must have a valence of III. When brought in contact with water the nitrogen is theoretically considered to be oxidized to its maximum valence, V, with which it can hold the four hydrogen atoms and one hydroxyl group. This hydroxyl group can be exchanged for other radicals similarly, as though it were attached to a single positive element. The formation of ammonium hydroxide is shown graphically as follows:



NH_3 Ammonia gas (Nitrogen trihydride) — H_2O Water — $NH_4(OH)$ Ammonium hydroxide

The univalent hydroxyl radical, —OH, consisting of one atom of hydrogen and oxygen, cannot exist by itself, and is a characteristic part of bases, alcohols, oxyacids, etc.

Radicals play a most important part in the various reactions of analytic and synthetic chemistry, readily interchanging with atoms in chemical reactions. Radicals are so closely interwoven in the theories and laws concerning the formation of acids, bases, and salts that consideration of them will be continued in the discussion of the latter.

Acids, bases, and salts are the three main types of inorganic chemical compounds and any one of the three may be either a binary or ternary compound.

Acids are compounds of hydrogen with a negative element or radical, and are sometimes considered as salts of hydrogen. They possess a sour taste when diluted, saturate bases (neutralization), destroy or change the color of litmus

or other indicators, have a corrosive action on animal and vegetable tissues, and in aqueous solution dissociate into hydrogen ions, producing the characteristic reaction of the substance, and electronegative elements. All acids contain hydrogen which is readily replaceable by a metal, the product being a salt.

Acids are divided into two classes, binary (hydrogen, hydro, or halogen) acids which are compounds of the halogens and hydrogen, and ternary (oxy or oxygen) acids in which hydrogen is linked by means of oxygen to negative radicals containing oxygen, as $HO—NO_2$. Examples of each are shown in the table following.

Hydrogen acids		Oxygen acids	
Hydrochloric acid	HCl	Sulfuric acid	H_2SO_4
Hydrobromic acid	HBr	Nitric acid	HNO_3
Hydriodic acid	HI	Phosphoric acid	H_3PO_4
Hydrofluoric acid	HF	Carbonic acid	H_2CO_3
		Chloric acid	$HClO_3$

The strength of an acid is said to depend upon the degree to which it can dissociate or ionize. When an oxide of a negative element is dissolved in water an acid is produced. Theoretically, then, in order to manufacture an acid the first step is to produce an oxide of the element. Such an oxide is known as an acid anhydride, which may be described as an acid from which all hydrogen with sufficient oxygen to form water has been removed. For purposes of nomenclature all ternary acids are considered to be derived from acid anhydrides.

A molecule of an acid may be said to be composed of two parts—its replaceable hydrogen and the remainder of the molecule. This remainder is known as an acid radical or residue. If an acid contains one atom of hydrogen to a molecule, as does hydrochloric acid, one atom of any univalent or monovalent element may replace that hydrogen to form a normal salt, but as an atom of a divalent element is equivalent in strength, or valence, to two hydrogen atoms one divalent atom can replace the hydrogen contained in two molecules of such an acid. Conversely, if the acid contains two atoms of replaceable hydrogen to a molecule, as sulfuric acid, it is evident that it must require two atoms of a univalent or monovalent element, or one atom of a divalent element to replace it. For that reason radicals are regarded as groups not broken up easily, which act as a unit in most reactions, and which possess valence (or basicity) the same as do elements, this basicity being determined by the number of replaceable hydrogen atoms in a molecule of the acid of which they are the residue; for example:

Acid	Radical	Basicity
HNO_3	$-NO_3$	1
$HClO_3$	$-ClO_2$	1
H_2CO_3	$=CO_3$	2
H_2SO_4	$=SO_4$	2
H_3PO_4	$\equiv PO_4$	3
H_3BO_3	$\equiv BO_3$	3

The formula for a radical may be written correctly and no attention paid to the valence of any particular element in it, since these elements are acting as a group, or whole, and, as stated before, the valence or basicity of the radical or group is governed solely by the number of replaceable hydrogen atoms orig-

inally combined with them in the acid of which they are the residue. Observing the matter in this light, it is clear that by knowing the valence of the base to be used and the formula of the acid from which the radical is derived, the two then may be combined exactly in the same manner as would be two elements to form any binary compound. For example, it is desired to write the formula for zinc carbonate. Zinc has a valence of two. Its symbol, Zn, is written down. A carbonate must come from carbonic acid, since carbon is the characteristic element in that radical and "ate" salts come from "ic" acids. The formula for carbonic acid is H_2CO_3. The carbonate radical therefore must be CO_3 and is written down alongside and next after the symbol for zinc. Carbonic acid, containing two atoms of replaceable hydrogen to a molecule, shows that the carbonate radical must be dibasic and accordingly will exactly match in valence strength with one atom of zinc. The formula for zinc carbonate therefore is $ZnCO_3$. In other words, zinc being divalent, is equal in combining power to two hydrogen atoms and can replace them in any acid. Sodium is univalent, and it would require two atoms of that element to replace all the hydrogen in a molecule of carbonic acid, so that the formula for sodium carbonate would be Na_2CO_3. Whenever a whole radical must be used in a formula more than one time (unless it is a binary radical) it is necessary to enclose it within parentheses and multiply it by using a small numeral suffixed somewhat below the parentheses, as is done in the case of multiplying a single atom. For example—

Calcium chlorate---------- $Ca(ClO_3)_2$
Ferric sulfate------------- $Fe_2(SO_4)_3$
Ferrous phosphate--------- $Fe_3(PO_4)_2$

Carbonate radicals generally are broken up when brought in contact with an acid or when heated, and therefore when a carbonate reacts with an acid another carbonate is not formed, but carbon dioxide and water are among the products. This is shown by the equation marked (*a*) following. When heated, all carbonates except those of the alkalies will produce carbon dioxide and an oxide of the element with which it is combined as a carbonate, as shown by the equation marked (*b*).

(*a*) $CaCO_3+H_2SO_4 \rightarrow CaSO_4+CO_2+H_2O$
(*b*) $CaCO_3+\text{Heat} \rightarrow CaO+CO_2$

Very few salts are actually formed by treating a metal or its base with an acid, although practically all of them can be so produced. Many of the acids do not exist as such, and others, though formation is possible, are of such a weak or unstable nature that their use outside of a laboratory would be most impracticable, and in most instances formation of salts by such a method would prove too costly. In practice, therefore, compounds are produced usually by other methods, an outline of which will be given later.

Most of the acid-forming elements are polyvalent, and therefore they can unite with oxygen to produce more than one oxide. In the cases of those elements which form only two oxides, as nitrogen or arsenic, the nomenclature is easy and is carried out exactly as described for all binary compounds; that is, there would be nitrous and nitric oxides and arsenic and arsenious oxides. In examining chlorine it will be seen that this element possesses four distinct sets of valences, and therefore can unite with oxygen in four ways. It develops that chlorine, as well as others of these polyvalent elements, has two sets of valences with which it unites with oxygen much more often than it does with its other two sets. Also that these more common compounds with oxygen are much more stable. To the compounds formed by these two sets of

valences the endings *ic* and *ous* are given. Thus there are chlor*ic* oxide (Cl_2O_5) and chlor*ous* oxide (Cl_2O_3), in which the valence of chlorine is V and III, respectively. For the oxides next above the *ic* form the prefix *per* is used, and for the oxide next below the *ous* form the prefix *hypo.* Accordingly the oxides of chlorine are named as follows: *Per*chlor*ic* oxide, chlor*ic* oxide, chlor*ous* oxide, and *hypo*chlor*ous* oxide. Such oxides also may be named in other ways; for example, chloric oxide correctly may be called chloric oxide, chlorine pentoxide, or chloric anhydride.

As has been said, an acid is produced by dissolving a negative oxide (acid anhydride) in water, and the acid so produced inherits the name of the oxide, the word "acid" simply being substituted for the word "oxide"; therefore sulfuric oxide produces sulfuric acid, nitric oxide produces nitric acid, and hypophosphorous oxide produces hypophosphorous acid, and chloric, iodic, and bromic acids are derived, respectively, from chloric, iodic, and bromic anhydrides. The negative element which unites with oxygen to form an acid anhydride is known as the "characteristic" element of that oxide and of the acid produced from it. *It is the element that gives the acid its name;* e. g., sulfur is the characteristic element in sulfuric acid, etc. The reaction that actually occurs when an anhydride is dissolved in water is that the molecule of the anhydride unites with the molecule of the water to form one or more hydroxyl groups, so that, if lines are used to designate valence or bonds, the transformation that takes place is as shown in the following graphic formula of sulfuric acid:

$$\left.\begin{array}{c}\text{Sulfuric anhydride}\\ \text{Sulfuric trioxide}\end{array}\right\} \quad + \quad \text{Water} \qquad \text{yields} \qquad \text{Sulfuric acid}$$

$$\mathrm{S}\begin{array}{l}=\mathrm{O}\\ =\mathrm{O}\\ =\mathrm{O}\end{array} \quad + \quad \mathrm{O}\begin{array}{l}-\mathrm{H}\\ -\mathrm{H}\end{array} \quad \rightarrow \quad \mathrm{S}\begin{array}{l}-\mathrm{O}-\mathrm{H}\\ -\mathrm{O}-\mathrm{H}\\ =\mathrm{O}\\ =\mathrm{O}\end{array}$$

$$SO_3 \quad + \quad H_2O \quad \rightarrow \quad H_2SO_4$$

It should be noted that it is only the hydrogen contained in the hydroxyl group of a ternary acid that can be replaced by a metal or a base. Usually in all inorganic acids all of the hydrogen is so combined but not always. The formula for phosphorous acid is H_3PO_3, but only two of the hydrogen atoms can be replaced for the reason that only two are contained in hydroxyl groups, as is shown by the graphic formula of that acid:

Phosphorous acid

$$\mathrm{P}\begin{array}{l}-\mathrm{O}-\mathrm{H}\\ -\mathrm{O}-\mathrm{H}\\ -\mathrm{H}\\ =\mathrm{O}\end{array}$$

$$H_3PO_3$$

Experiments have proven that hydrogen not so contained is not replaceable by a positive element, and as phosphorous acid contains hydrogen that is not part of a hydroxyl group it is therefore one in which all of the hydrogen cannot be replaced. (Some authorities question the graphic formula of phosphorous acid as shown.)

Acids are also classed according to their basicity, which is determined by the number of hydrogen atoms they contain that are replaceable by monovalent positive atoms. Acids having one replaceable hydrogen atom, as hydrochloric (HCl), are known as *monobasic,* those with two, as sulfuric (H_2SO_4), as *dibasic,*

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those with three, as phosphoric (H_3PO_4), as *tribasic*, etc. Any acid containing more than one replaceable hydrogen atom may be termed a *polybasic* acid.

Tables showing examples of the two classes of inorganic acids are given next.

BINARY OR HYDRACIDS

Name	Formula	Name	Formula	Name	Formula
Hydrobromic	HBr	Hydrocyanic	HCN	Hydriodic	HI
Hydrochloric	HCl	Hydrofluoric	HF	Hydrosulfuric	H_2S

These acids form salts whose names terminate in the ending *ide* and the prefix *hydro* is not used in naming the salt. Thus hydrochloric acid produces chlorides and hydrosulfuric acid produces sulfides.

TERNARY OR OXYACIDS

Name	Formula	Name	Formula	Name	Formula
Bromic	$HBrO_3$	Perchloric	$HClO_4$	Pyrosulfuric	$H_2S_2O_7$
Bromous	$HBrO_2$	Chloric	$HClO_3$	Sulfuric	H_2SO_4
Hypobromous	$HBrO$	Chlorous	$HClO_2$	Thiosulfuric	$H_2S_2O_3$
Arsenic	H_3AsO_4	Hypochlorous	$HClO$	Sulfurous	H_2SO_3
Arsenious	H_3AsO_3	Iodic	HIO_3	Hyposulfurous	$H_2S_2O_4$
Pyroboric	$H_2B_4O_7$	Nitric	HNO_3	Pyrophosphoric	$H_4P_2O_7$
Boric	H_3BO_3	Nitrous	HNO_2	Phosphoric	H_3PO_4
Metaboric	HBO_2	Silicic	H_4SiO_4	Metaphosphoric	HPO_3
Permanganic	$HMnO_4$	Metasilicic	H_2SiO_3	Phosphorous	H_3PO_3
Manganic	H_2MnO_4	Chromic	H_2CrO_4	Hypophosphorus	H_3PO_2
Carbonic	H_2CO_3	Persulfuric	$H_2S_2O_8$	Cyanic	$HCNO$

Salts formed by these acids are named as follows: Acids whose names end in *ic* produce salts whose names end in *ate*; acids whose names end in *ous* produce salts whose names end in *ite* and any prefix occurring in the name of the acid before the part referring to the "characteristic" element also is used in the name of the salt. Thus sulfuric acid produces sulf*ates*, sulfurous acid produces sulf*ites*, and *per*sulfuric acid produces *per*sulf*ates*.

Some of these acids may not actually exist and some are so unstable that their actual use, outside a laboratory, would be impracticable, but salts of all of them are existent.

The formulas given in these tables are molecular formulas in that they express the content, qualitatively and quantitatively, of a molecule.

Bases are compounds in which a positive element or radical is united with a hydroxyl (—OH) group. They are capable of reacting with acids to form salts, and when dissolved in water they dissociate, yielding hydroxyl ions, which produce their characteristic alkaline reaction, and electropositive elements. Because they contain the hydroxyl group they are also known as *hydroxides*. Hydroxides of the alkali-metals are called alkalis, while those of calcium, strontium, barium, and magnesium are called alkaline earths. Alkalis are known as mild and caustic, according to the strength of their action.

Bases have several characteristic properties such as: Interaction with acids to form salts; alkaline reaction, if soluble; restoration of the blue color of substances reddened by acids, as litmus; soapy, slippery feeling, if soluble; power to saturate or neutralize acids, taking away their characteristic properties; and the effervescence of most mild varieties with acids, giving off carbon dioxide (CO_2).

In theory, for purposes of nomenclature, bases are regarded as being formed either by the direct union of some basic element and oxygen, as calcium oxide, CaO, or by the action of a positive element or its oxide on water, whereby a hydroxide is formed, as potassium hydroxide, KOH. A hydroxide is a compound in which an atom of an element is combined with one or more groups of hydroxyl ($-OH$). Being a radical, hydroxyl cannot exist by itself, and when combined as a hydroxide it may be regarded as water in which one of the hydrogen atoms has been replaced by another element. Hydroxides are regarded as binary compounds, as the group ($-OH$) acts much the same as a univalent element. Hydroxides must not be confused with hydrates. The latter are additive compounds of one or more whole molecules of water with a molecule of some other compound, such as, for instance, terpin hydrate ($C_{10}H_{20}O_2.H_2O$).

When acids are mixed with bases mutual rearrangements of the compositions of these substances take place, and the products of this interaction between acids and bases are known as salts. This term should not be confused with the common name of sodium chloride, "salt."

The saturating or neutralizing power of bases is determined by the number of hydroxyl groups present. When one hydroxyl group is present a base is known as *monohydric* (sodium hydroxide, $NaOH$); when two are present a base is known as *dihydric* (barium hydroxide, $Ba(OH)_2$); etc.

Salts are the products or compounds formed when all or part of the replaceable hydrogen in an acid has been replaced by a positive element or a base. They are classified according to the amounts of the acids and bases entering into the interaction, being known as normal or neutral, acid or mixed, double, and basic or oxy or sub.

Normal or *neutral salts* are those in which *all* replaceable hydrogen of an acid has been replaced by a metal or base, as in calcium sulfate ($CaSO_4$).

Acid salts are those in which the amount of the base is not sufficient to allow complete interaction and only a part of the replaceable hydrogen of the acid can be replaced by a metal or base, as sodium acid sulfate ($NaHSO_4$). Because of the presence of this unreplaceable hydrogen, the names of acid salts usually contain the word acid and their formulas always contain an H. They also are designated as hydrogen salts or, instead of using the word acid or hydrogen in their names, the prefix "bi" may be used, and when so used always denotes an acid salt. Its use in any other kind of compound is incorrect, and therefore should never be used in place of "di" to indicate a double quantity. Bichloride of mercury is an example of the incorrect use of this word. Sodium acid sulfate, then, correctly may be called by that name or sodium hydrogen sulfate or sodium bisulfate.

Double salts are those in which the hydrogen of an acid has been replaced by two or more elements, as in sodium and potassium sulfate, $NaKSO_4$, or by an element and a radical, as in sodium ammonium sulfate, $NaNH_4SO_4$.

Basic salts are those which contain more base than is required to form a normal salt and are regarded generally as being formed when there is not enough acid present to neutralize the base. An example of a basic salt is bismuth subnitrate or, as it is sometimes called, bismuth oxynitrate. This basic salt is prepared by the decomposition of bismuth nitrate in a large quantity of water according to the following interaction:

$$Bi(NO_3)_3 + 2H_2O \rightarrow BiO(NO_3).H_2O + 2HNO_3$$

Bismuth nitrate + Water gives Bismuth subnitrate + Nitric acid

In the interaction shown it might seem that there was sufficient nitric acid present to neutralize the base (a metal in this case) but immediately water is added to the normal salt (bismuth nitrate), two of the acid anhydrides (NO_3) in it combine with two of the hydrogen atoms in the water to form nitric acid, so it can be seen that there is not enough acid (NO_3) present in bismuth subnitrate to neutralize the base, the base bismuth having a valence of 3 while the valence of the acid anhydride is but 1.

Just as the acids are named from the anhydrides from which they are derived, so, too, are salts named from the acid which produces them, by naming the first or basic part of the salt just as described for the basic part of binary salts and dropping the ending of the names of the acid and substituting other endings. As the salt of a binary acid is itself a binary compound its name must end in "ide" so that from a reaction of zinc and hydrochloric acid would be obtained zinc chloride. The names of all ternary acids, as has been learned, end either in "ous" or "ic" and the names of the salts from these acids end in "ite" or "ate" respectively. In all salts, except binaries, any prefix the acid may have had is carried over and incorporated in the name of the salt. Thus it may be said that "ous" acids produce "ite" salts, "ic" acids produce "ate" salts, "per–ic" acids produce "per–ate" salts, "hypo–ous" acids produce "hypo–ite" salts, and "meta–ic" acids produce "meta–ate" salts. Similarly, any other prefix the name of a specific acid may have is inherited by any salt it may produce, as, for instance, pyrophosphoric acid produces pyrophosphates.

All rules are tested by the exceptions thereto, and it must not be inferred from anything that has been said that in all instances the facts will adhere rigidly to the theory laid down. The scheme of nomenclature for acids and salts herein described is conceived as the one most nearly fitting all cases. It is purely theoretical and conceives that all acids are formed from their respective anhydrides, as described, and further, that all salts are derived directly through the action of an acid on a positive element, or upon an oxide or hydroxide of a positive element (bases).

For the reason that ternary acids are produced from binary compounds and all other ternary compounds in turn are derived from the acids, in order to determine the formula of any salt, it is necessary that the formula of every acid listed in the tables of inorganic acids on page 684 be committed to memory. Just as it is necessary to know the valences of the different elements before it is possible to accurately write the correct formula for any acids, so is it necessary to know these formulas before it will be possible to write the formula of any compound (salt) derived from them.

The nonmetals.

HYDROGEN.—Symbol: H; Atomic number: 1; Atomic weight: 1.0078; Valence: I; Molecular formula: H_2.

Occurrence: Hydrogen is one of the most widely distributed elements. It forms one-ninth of the water of the earth, one one-hundredth per cent of the air, and is a constituent of nearly all organic material.

Properties: Pure hydrogen is an odorless, colorless, tasteless gas. It is the lightest substance known, one liter weighing 0.089783 Gm. at 0° C. and 760 mm. pressure. Because of this property "lighter-than-air" aircraft are inflated with it to give them buoyancy, but due to its inflammable nature its use for that purpose is extremely hazardous. Inasmuch as its molecules have great diffusibility nonporous containers are necessary to retain it.

Because of its activity in the nascent state, i. e., when being liberated from its compounds in the form of atoms, two atoms of hydrogen combine to form

a stable molecule. In this form it has little affinity for other substances, but in the nascent state or when its temperature is elevated, its behavior is quite the opposite. It burns with a nonluminous but intensely hot flame, combining with the oxygen of air to form water. This intense heat is put to practical use in the oxy-hydrogen torch employed to weld metals having a high melting point.

When a current of hydrogen is directed upon a mass of finely divided plat-

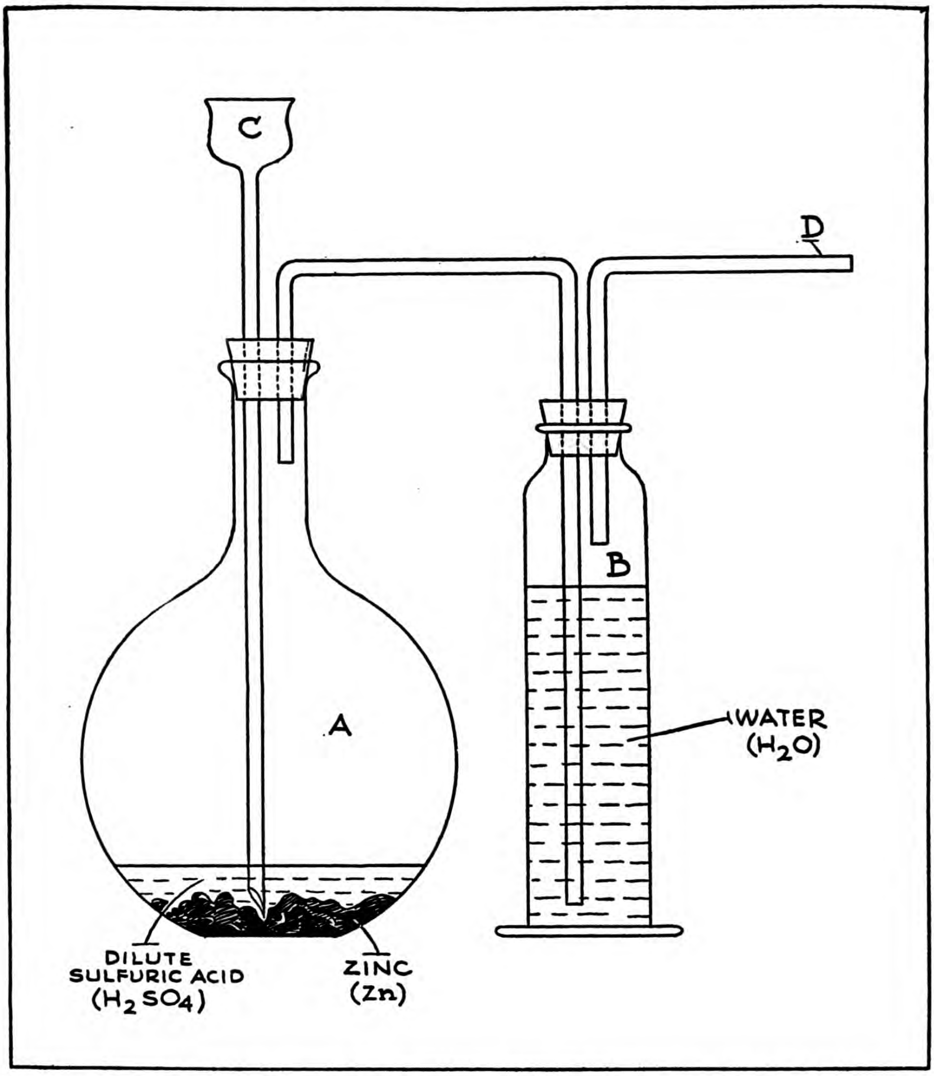

FIGURE 152.—Generation of hydrogen gas: (*a*) Generator; (*b*) wash bottle; (*c*) thistle tube; (*d*) outlet.

inum, the latter becomes incandescent. This results from the heat produced by the union of hydrogen with the oxygen occluded (absorbed) in the finely divided metal. The platinum undergoes no chemical change. Other metals and substances act in a similar manner, facilitating a chemical reaction without undergoing any chemical change themselves. These substances which accelerate such chemical reaction through their presence are known as *catalysts* and the action is termed *catalysis.*

Hydrogen combines with chlorine even more readily than with oxygen, but with most other nonmetals it does not unite unless in a nascent state. The

nascent state represents the element in its atomic condition at the moment of generation. While in the nascent state hydrogen is capable of reducing *ic* compounds to lower *ous* compounds, or metallic oxides and chlorides to their metals:

$$2FeCl_3+H_2 \rightarrow 2FeCl_2+2HCl$$
$$Fe_2O_3+3H_2 \rightarrow 3H_2O+2Fe$$

Isolation.—Hydrogen may be prepared by the electrolysis of acidified water,

$$2H_2O \rightarrow 2H_2+O_2$$

or by the action of dilute acids upon a metal, the gas being collected over water (fig. 152):

$$Zn+H_2SO_4 \rightarrow ZnSO_4+H_2\uparrow$$

When the zinc is brought into contact with the acid solution an equivalent weight of the metal passes into solution in the ionic condition. The hydrogen ions recover their missing electron from the zinc atoms and are liberated as molecular (gaseous) hydrogen. This giving up of an electron by the metallic atoms shows that they have a smaller affinity for their electrons than does hydrogen. The reaction of the metal and the acid is attended by the evolution of considerable heat and experiments have shown that the heat evolved when various metals are used is quite different, which shows that the "chemical activity" of the metals is different.

Some metals, like sodium, react vigorously with water at ordinary temperatures displacing hydrogen, while others, like iron, must be heated before the hydrogen is displaced. This is because sodium is more active than iron, and the same difference exists when they are brought in contact with an acid.

As a result of this difference in chemical activity it has been found that certain metals will displace others in acid solutions and it is possible to arrange all the metals in the order in which they will displace each other in this way. Such an arrangement is known as the *electrochemical series of the metals*, and also as the *electromotive series.*

Following is a list of the common metals showing their position in the electrochemical series according to their decreasing chemical activity.

Lithium	Aluminum	Nickel	Copper
Potassium	Manganese	Tin	Mercury
Sodium	Zinc	Lead	Silver
Strontium	Chromium	HYDROGEN	Platinum
Barium	Iron	Antimony	Gold
Calcium	Cadmium	Bismuth	
Magnesium	Cobalt	Arsenic	

All the metals above a given one in this list will displace it from solutions of its compounds, while it, in turn, will displace all those of lower position. Sodium and potassium react violently with water at room temperature; magnesium burns in steam while iron must be heated before it reacts with steam; and the metals below iron do not react with steam unless excessive temperatures are employed.

The place of hydrogen in the electrochemical series is most interesting. All those metals which precede it will, under ordinary conditions, evolve hydrogen from dilute acids, while those which follow it will not.

All the metals down to and including mercury combine directly with oxygen, while the oxides of gold and platinum are formed indirectly. If the oxides of the first ten metals are heated in hydrogen no reduction takes place, but those oxides from iron to copper inclusive are reduced by heating with hydrogen. The oxides of the last four metals are reduced by heat alone.

THE CHLORINE FAMILY OR "HALOGENS".—Chlorine, bromine, iodine and fluorine exhibit such a close resemblance as elements, and in their compounds, that they are grouped into a family known as *halogens* or "salt formers." They all unite with metals to form salts such as sodium chloride.

CHLORINE.—Symbol: Cl; Atomic number: 17; Atomic weight: 35.457; Valence: I; Molecular formula: Cl_2.

Occurrence.—In Nature chlorine does not occur free but is found abundantly in combination with sodium in sea-water and salt mines. It is not very abundant in the vegetable kingdom, but in the animal kingdom, combined with sodium, it is a constituent of the body fluids.

Properties.—Chlorine is a yellowish-green gas with a suffocating odor and when inhaled has a corrosive effect on the mucous membrane of the respiratory tract. Next to fluorine, chlorine is the most active element of the non-metal group, readily combining with all the elements except oxygen, the inert gases and some of the rarer metals. A mixture of chlorine and hydrogen combines with explosive violence when a flame or spark is applied, upon contact with a platinum sponge, or upon exposure to the sun's rays. Because of its intense affinity for hydrogen, chlorine indirectly becomes a powerful oxidizing agent by liberating nascent oxygen from the water in moistened materials.

Isolation.—Chlorine may be isolated by the electrolysis of HCl or chlorides,

$$2HCl \rightarrow H_2 + Cl_2$$

or through the oxidation of HCl by higher metallic oxides with the application of moderate heat:

$$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$$

It is extensively used as a bleaching agent in the form of chlorinated lime and is employed in water purification and sewage disposal as a powerful germicide and deodorizer. Chlorine was the first gas used in modern chemical warfare, and has a demoralizing effect upon troops because of its irritant, suffocating action. Prior to the development of efficient masks it caused heavy casualties.

Hydrochloric acid, HCl, is one of the gaseous products ejected from volcanoes and is a normal constituent of the gastric juices of mammals, being present in quantities from 0.1 to 0.4 per cent. It is a colorless gas with a sharp, suffocating odor and acid taste. The dry gas neither acts on metals nor reddens litmus. It fumes in moist air and is very soluble in water. In contact with most metallic oxides it decomposes them to form water and a chloride:

$$Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$$

The concentrated aqueous solution, commonly called muriatic acid and containing 35 to 37 per cent HCl, is a colorless, corrosive fluid with a strong acid taste and pungent odor. Most metals dissolve in it, liberating hydrogen.

Certain typical reactions are produced by strong acids acting upon various substances, and examples of them are shown in the following equations in which HCl is the strong acid used:

1. Metals are acted upon by acids, hydrogen being displaced and a salt formed:

$$2HCl+Fe \rightarrow FeCl_2+H_2\uparrow$$

2. Acids react with oxides of the metallic elements, a salt and water being formed:

$$FeO+2HCl \rightarrow FeCl_2+H_2O$$

3. Acids react with metallic hydroxides to form a salt and water:

$$Fe(OH)_2+2HCl \rightarrow FeCl_2+2H_2O$$

4. An acid reacts with a carbonate to form a new salt and water, with the liberation of carbon dioxide:

$$FeCO_3+2HCl \rightarrow FeCl_2+H_2O+CO_2\uparrow \ (H_2CO_3)$$

5. In general there is a tendency for the active acids to react with metallic salts, liberating the acid of the salt and forming a new salt:

$$FeSO_4+2HCl \rightarrow H_2SO_4+FeCl_2$$

BROMINE.—Symbol: Br; Atomic number: 35; Atomic weight: 79.916; Valence: I; Molecular formula: Br_2.

Occurrence.—The chief sources of bromine are from magnesium bromide in brine wells and in sea-water. The magnesium, calcium, and sodium salts of bromine are found in many rock salt deposits.

Properties.—Bromine is a reddish-brown, intensely caustic liquid which liberates orange-red vapors of a suffocating odor resembling that of chlorine. It is similar to chlorine in chemical action, although less active, chlorine displacing bromine from salts. In the presence of water it is an active oxidizing agent:

$$H_2S+4Br_2+4H_2O \rightarrow H_2SO_4+8HBr$$

Isolation.—The various methods employed for the isolation of bromine depend upon its displacement from bromine salts by chlorine:

$$Cl_2+2NaBr \rightarrow 2NaCl+Br_2$$

Hydrobromic acid, HBr, is a colorless, heavy gas, with a sharp, irritating odor and acid taste; it is very soluble in water, the concentrated solution fuming in air. Solutions of the acid decompose upon standing, bromine being liberated. It combines with most metals to form salts, called bromides, which are used extensively in medicine and photography:

$$NaOH+HBr \rightarrow NaBr+H_2O$$

Hydrobromic acid is prepared by the action of an acid upon a bromide:

$$3KBr+H_3PO_4 \rightarrow K_3PO_4+3HBr$$

Sulfuric acid cannot be used due to the liberation of sulfur dioxide and molecular bromine.

IODINE.—Symbol: I; Atomic number: 53; Atomic weight: 126.92; Valence: I; Molecular formula: I_2.

Occurrence.—In small quantities, iodine is distributed throughout Nature combined with sodium, potassium, calcium, and magnesium. In sea-water, iodides are absorbed by sea-weeds, known as kelp, and certain species of sponges, which formerly comprised the chief source. Most of the present world supply is obtained from the iodate impurities of salpeter found in Chile and

Peru. Traces of iodine are found in the blood and certain portions of the animal body, as the thyroid and the liver.

Properties.—The bluish-black rhombic plaques of pure iodine have a metallic luster, distinctive odor, acrid taste and neutral reaction. Iodine is slightly soluble in water, but in the presence of alkali iodides or hydriodic acid its solubility is greatly increased. One Gm. is soluble in 12.5 parts of alcohol. It resembles chlorine and bromine in its chemical reactions, although it is less active. Its affinity for hydrogen is comparatively weak, but the reverse is true in its relation to oxygen, for chlorine and bromine are replaced in their oxygen compounds by iodine:

$$2KClO_3+I_2 \rightarrow 2KIO_3+Cl_2$$

Iodine unites with the positive element in a solution of alkali hydroxides to form iodides and iodates:

$$3I_2+6NaOH \rightarrow 5NaI+NaIO_3+3H_2O$$

Upon treatment with ammonia water, it forms a very explosive compound, nitrogen tri-iodide (NI_3).

Isolation.—Iodine is extracted from Chilean saltpeter by precipitation from the mother liquor (after the removal of the sodium nitrate) with a mixture of acid and neutral sodium sulfite:

$$2NaIO_3+3Na_2SO_3+2NaHSO_3 \rightarrow 5Na_2SO_4+H_2O+I_2$$

The precipitate is collected on muslin, strained, dried, and purified by sublimation.

Iodine and its salts are used extensively in medicine and photography.

Hydriodic acid, HI, is a colorless, heavy gas with a sharp penetrating odor, fuming in air and very soluble in water. This is a very unstable compound, decomposing upon exposure to air. As a reducing agent it is very active due to the readiness with which it resolves into iodine and nascent hydrogen; hence, it is employed extensively in organic synthesis. It may be prepared by the action of phosphoric acid upon potassium iodide with the application of heat:

$$3KI+H_3PO_4 \rightarrow K_3PO_4+3HI$$

Most of the compounds known as *iodides* are very soluble in water and may be prepared by the direct union of the elements in water:

$$Fe+I_2 \rightarrow FeI_2$$

or by the addition of iodine to the hydroxide of an alkali metal:

$$3I_2+6KOH \rightarrow 5KI+KIO_3+3H_2O$$

The mass is then burned with charcoal to reduce the iodate:

$$KIO_3+3C \rightarrow KI+3CO$$

FLUORINE.—Symbol: F; Atomic number: 9; Atomic weight: 19.00; Valence I; Molecular formula: F_2.

Occurrence.—Fluorine occurs mainly as calcium fluoride (fluorspar), CaF_2, widely distributed throughout the world, and as sodium and aluminum fluoride (cryolite), $3NaF.AlF_3$, found in Greenland.

Properties.—Fluorine is the most active element known, combining with hydrogen even in the dark with explosive violence, and decomposing water with the formation of hydrogen fluoride and ozone. Many organic substances are ignited upon contact with it.

Isolation.—It is prepared by the electrolysis of anhydrous hydrofluoric acid.

Hydrofluoric acid, anhydrous, HF, is a colorless liquid which vaporizes as an intense, irritating, corrosive gas. In the presence of water it corrodes glass, porcelain, earthenware and most of the metals, but has slight effect upon the nonmetals. Its action upon silica makes it very useful in etching glassware.

The gaseous envelope which surrounds the earth is called the atmosphere. It is composed of:

	Percent
Nitrogen (N)	78
Oxygen (O)	21
Argon (A)	00.94
Carbon dioxide (CO_2)	00.03
Hydrogen (H)	00.01
Neon (Ne), Helium (He), Krypton (Kr), Xenon (Xe), Niton (Nt)	00.02

Except for carbon dioxide, these elements as found in the atmosphere are in a free and uncombined state, so that air is a mixture.

Helium, neon, argon, krypton, xenon, and niton are completely inactive, uniting with no known substance or element to form compounds and having only one atom in their molecules. They are the so-called *inert gases*, existing only in the atomic state.

OXYGEN.—Symbol: O; Atomic number: 8; Atomic weight: 16.00; Valence II; Molecular formula: O_2.

The discoverer of this element is regarded as Joseph Priestley of England who in 1774 obtained an "air", as he called it, from the heating of mercuric oxide over mercury in which he found "that a candle burned * * * with a remarkably brilliant flame." Although it is certain that Scheele of Sweden had isolated this gas in 1772 and there is little doubt that other experimenters had obtained oxygen long before either Scheele or Priestley, credit for its discovery is given to Priestley because he was the first to publish the results of his experiments and make them known to the world. Lavoisier of France, with whom begins modern chemistry, developed experiments showing its source and properties and in 1784, because he thought the properties of acids were due to the presence in them of this substance, he gave it the name of oxygen, which is derived from Greek words meaning "sour" and "I produce," or roughly, "acid former," sourness being a characteristic of acids.

Oxygen is the most useful element known to man and is essential to animal life in the repair of tissues and the furnishing of heat and energy. It is vital in developing heat, light, and power from burning fuel. It is used in the acetylene torch, in special high-temperature furnaces and in treating respiratory distress from pneumonia, heart disease, and severe asthma. Submarine operations, diving, caisson work, high-altitude flying and rescue-breathing apparatus all require oxygen. It is mixed with anæsthetic gases in the production of general anæsthesia.

Occurrence.—Oxygen makes up one-half of all matter known to man, eight-ninths of the water of the ocean, and more than one-fifth of the atmosphere. Two-thirds of the human body is combined oxygen. Ordinary soil and rocks contain about 50 per cent oxygen. It occurs free only in the air, its most natural and cheapest source.

Properties.—Oxygen is a colorless, odorless, tasteless gas which is 1.105 times as heavy as air. One liter weighs 1.429 Gm. measured at 0° C. and a barometric pressure of 760 mm. It may be liquefied at and below minus 118° C., but no pressure is great enough to compress it to a liquid above minus 118° C. which may then be called its *critical temperature.* At this critical temperature a pressure of 50 atmospheres is required to liquefy oxygen, and hence is called the *critical pressure.*

Liquid oxygen is light blue in color and boils at minus 182.5° C. under atmospheric pressure. Frozen oxygen is a pale blue, snowlike solid, melting at minus 227° C. It is only slightly soluble in water, 30 cc per liter.

While oxygen is only moderately active at ordinary temperatures, it is very active at elevated temperatures and unites with all the elements except fluorine and the inert gases.

Iron will rust in the air at ordinary temperatures but when heated red hot and placed in oxygen, will actually burn:

$$3Fe+2O_2 \rightarrow FeO.Fe_2O_3$$

A compound of oxygen with an element or radical is termed an *oxide.* According to their observed composition they are known as *mon*oxides (R_2O), and (RO), *sesqui*oxides (R_2O_3), *di*oxides (RO_2), *tri*oxides (RO_3) *tetra*oxides (RO_4), *pent*oxides (R_2O_5), and *hept*oxides (R_2O_7), R in these formulas representing any element.

Oxides are divided into two general classes according to the nature of the compounds resulting from their union with water. Oxides yielding acids with water are called *acidic oxides,* and those yielding bases with water are called *basic oxides.* Acidic oxides, also called acid anhydrides, combine with basic oxides to form salts, as sulfur trioxide (SO_3) which combines with barium oxide (BaO) to form barium sulfate ($BaSO_4$). Basic oxides unite with acids and acidic oxides to form salts, as copper oxide (CuO) unites with diluted sulfuric acid (H_2SO_4) to form copper sulfate ($CuSO_4$), and sodium oxide (Na_2O) unites with sulfur trioxide (SO_3) to form sodium sulfate (Na_2SO_4).

Oxides consisting of a metallic element and oxygen are known as *metallic oxides,* and those that do not form acids with water, that cannot be obtained by removing water from acids, and that do not form salts by uniting with either basic or acidic oxides or with acids are known as *neutral oxides.* Oxides that combine with acids to form salts corresponding with oxides containing less oxygen than they do themselves are termed *peroxides,* as hydrogen dioxide (H_2O_2) and barium dioxide (BaO_2).

Elements whose oxides react with water to form bases are called *metals* and elements whose oxides react with water to form acids are called *nonmetals.*

When substances react, heat is usually liberated and if this reaction becomes vigorous enough to produce light it is called *combustion.* As a rule this term is applied to a union of oxygen with other substances. The temperature at which a substance in contact with air bursts into flame is called its *kindling temperature.* Reactions accompanied by heat are *exothermic* and those requiring the application of external heat to keep them going are *endothermic.*

The unit of measure for heat is the *calorie* which is the amount of heat required to raise the temperature of 1 Gm. of water from zero to 1° C. The British thermal unit (B. T. U.) is the amount of heat required to raise the temperature of 1 pound of water 1° F. Since 1 pound contains 453 Gm. and 1° F. is five-ninths of 1° C., the B. T. U.=5/9 of 453 or 252 calories. The number of calories liberated when the formula weight (molecular weight in

grams) of any pure substance burns completely is the *heat of combustion.* When a gram of substance *oxidizes* slowly it liberates the same amount of heat as when it burns violently. If the heat from a slow oxidation is not conducted away fast enough it accumulates, finally bringing the temperature of the substance to the *ignition point.* This is called *spontaneous combustion.* Oil-soaked rags are most likely to ignite spontaneously and should be disposed of or placed in closed tin cans.

Isolation.—To obtain oxygen air is liquefied by pressure under reduced temperature and then allowed to evaporate. The more volatile nitrogen evaporates first and leaves the oxygen which is pumped into strong cylinders.

Electrolysis of water releases oxygen and hydrogen at the anode and cathode electrodes respectively but this method is expensive.

The heating of oxygen compounds is the most convenient laboratory method:

$2HgO$	+	Heat	→	$2Hg$	+	$O_2 \uparrow$
Mercuric oxide				Mercury		Oxygen
$2KNO_3$	+	Heat	→	$2KNO_2$	+	$O_2 \uparrow$
Potassium nitrate				Potassium nitrite		Oxygen
$3MnO_2$	+	Heat	→	Mn_3O_4	+	$O_2 \uparrow$
Manganese dioxide				Manganese oxide		Oxygen
$2BaO_2$	+	Heat	→	$2BaO$	+	$O_2 \uparrow$
Barium dioxide				Barium monoxide		Oxygen
$2KClO_3$	+	Heat	→	$2KCl$	+	$3O_2 \uparrow$
Potassium chlorate				Potassium chloride		Oxygen

The last reaction shown is much more complete and rapid, even at a relatively low temperature, when a small amount of manganese dioxide is present. The manganese dioxide aids the reaction without entering into the chemical changes and is therefore a catalyst. The oxygen is collected by displacement of water in inverted containers.

When an element exists in more than one form in the same physical state these forms are said to be *allotropic modifications* of the element, and the condition is known as *allotropism.* This condition is found in several of the elements, one of them being oxygen, the allotropic form of which is ozone, (O_3), with distinct physical properties.

Ozone is 1.5 times as heavy as oxygen and more active chemically. It is formed in the upper atmosphere by ultra-violet radiation. Static electrical discharges, lightning, static machines, and electric motors produce it from the oxygen of the air. The change from oxygen to ozone is represented thus: $3O_2 \rightleftarrows 2O_3$. It has a characteristic pungent odor and is rather unstable, tending to turn to oxygen. Its oxidation is done with the third atom releasing O_2. Thus: $H_2S + O_3 \rightarrow H_2O + S + O_2$. Formerly its chief use was as a bleaching agent and water purifier but now it has been largely replaced by chlorine. Produced electrically it is very effective as a deodorizing agent in homes, restaurants and theatres. Ozone is claimed to be healthful and stimulating.

Water, H_2O, is the most important of all chemical compounds. It occupies about five-sevenths of the earth's surface as lakes, rivers, and oceans; as ice and snow it covers the vast arctic and antarctic regions. In addition to its abundant natural occurrence, water is present in green plants to the extent of 75 per cent to 80 per cent and in the soil from 5 per cent to 20 per cent.

It exists in considerable quantities in the atmosphere from which it is precipitated in various forms.

Pure water is an odorless and tasteless liquid. In small quantities it is colorless, but with an increase in depth it assumes a bluish-green color. When cooled, water contracts, reaching its maximum density at 4° C. at which temperature 1 cc has a weight of 1 Gm. At 0° C. it solidifies, forming ice. The freezing point may vary slightly under certain circumstances, but the melting point remains constant at 0° C. At 100° C. water boils, forming steam. These figures are determined at a pressure of 760 mm. of mercury. Water evaporates constantly and the higher the temperature, the faster the rate. Increased pressure and vapor tension reduce the rate of evaporation.

If a little water or any other liquid is introduced into the vacuum of a mercury barometer, its molecules immediately begin to saturate the space with vapor, depressing the mercury column according to the temperature of the tube. If the height of the mercury column is subtracted from the true barometric reading, taken at the same temperature, the *vapor tension* of the liquid is obtained. At 0° C. water has a vapor tension of 4.6 mm. of mercury; at 100° C. it has a vapor tension of 760 mm. of mercury; that is, the vapor tension equals the atmospheric pressure. When this condition prevails, the water boils because the molecules can escape freely from the liquid. *The boiling point of a liquid is attained when its vapor tension just exceeds the pressure of the surrounding atmosphere.*

The importance of water is due largely to its capability of dissolving many substances, chemical reactions taking place readily in solutions of water. Many substances upon crystallizing from a solution, form molecular compounds containing water known as *water of crystallization.* The quantity of water taken up at a given temperature is always the same. In many instances the color of the salt is determined by the presence of this water of crystallization, as in copper sulfate, $CuSO_4.5H_2O$, which exhibits a blue color in the crystalline form but becomes white upon the loss of its water of crystallization. Water of crystallization may usually be removed at from 100° C. to 105° C.; the substance then assumes its amorphous form.

Water is composed of 2 parts of hydrogen and 1 part of oxygen. A mixture of these two gases, when ignited, explodes with violence to form water. By electrolysis water is resolved into these gases. The alkali metals and the alkaline-earth metals decompose water at ordinary temperatures while some of the other metals decompose it with the aid of heat. It combines with the oxides of some nonmetals to form acids.

Water, as found in Nature, contains many inorganic and organic substances in solution. To obtain pure water these substances are removed by distillation.

OXIDATION AND REDUCTION.—When an element combines with oxygen to form a compound it is said to be *oxidized* and the process or change which occurs is called *oxidation.* Compounds also may undergo oxidation when oxygen unites with one or more of the elements making up the compound. Oxidation usually is explained as being the addition of oxygen to an element or compound, the substance which furnishes the oxygen being termed the *oxidizing agent,* and the compound resulting from the combination with oxygen being called the *product,* an oxide of the element with which oxygen has combined. Examples of ordinary oxidation are:

Substance		Oxidizing agent		Product
$2Mg$	+	O_2	→	$2MgO$
Cr_2O_3	+	$KClO_3$	→	$2CrO_3+KCl$

In a broad sense oxidation includes all chemical reactions, in many of which oxygen takes no part, which result in the addition of electro-negative elements or radicals to an element or compound, examples being:

$$2FeCl_2+Cl_2 \rightarrow 2FeCl_3; \text{ and}$$
$$4FeSO_4+2H_2SO_4+O_2 \rightarrow 2Fe_2(SO_4)_3+2H_2O$$

When oxygen is partially or entirely removed from a compound it is said to be *reduced* and the process or change which occurs is called *reduction*, being usually explained as the removal of oxygen from a compound. The substance which unites with oxygen to remove it from the compound is termed the *reducing agent* and the substance resulting from the removal is called the *product*. Examples of ordinary reduction are:

Substance		Reducing agent		Product
KNO_3	+	Pb	→	KNO_2+PbO
Fe_2O_3	+	H_2	→	$2FeO+H_2O$

Reduction also may be explained as the partial or entire removal of electro-negative elements or radicals from a compound, examples being:

$2FeCl_3$	+	H_2	→	$2FeCl_2+2HCl$
$Fe_2(SO_4)_3$	+	H_2	→	$2FeSO_4+H_2SO_4$

Hydrogen and the metals form the electro-positive part of compounds; and oxygen, the nonmetals and most radicals the negative part. To facilitate the understanding of oxidation and reduction equations it is necessary to consider the valences of the substances involved from the viewpoint of the electronic theory. To determine the valence of each individual element in a ternary compound it is necessary to consider the hypothesis that the total sum of their respective valences is zero, i. e., the total positive electrical charges are exactly equal to the total negative electrical charges and the compound is neutral or has a valence of zero. In the compound H_2SO_4, hydrogen, each atom of which has a valence of plus 1 (H^+), has a total valence of plus 2 (H^{++}), and oxygen, each atom of which has a valence of minus 2 (O^{--}), has a total valence of minus 8 ($O^{--------}$). As but 2 of the 8 negative valences of oxygen have been satisfied or neutralized by the 2 positive valences of hydrogen, and as the compound H_2SO_4 is considered neutral or to have a valence of zero, the sulfur in this compound must therefore have valence of plus 6 (S^{++++++}). It is also considered that an element in an uncombined state has a valence of zero and it should be remembered that this consideration is not to be confused with the true valence of elements as regards their chemical affinity.

By applying this theory to the oxidation of sulfur, $S+O_2 \rightarrow SO_2$, it is found that the valence of the sulfur changes from zero to plus 4, while at the same time each oxygen atom changes from zero to minus 2. When the positive valence of an element is increased, that element is said to be *oxidized*.

As an example of this principle the oxidation of hydrochloric acid by manganese dioxide may be taken:

$$MnO_2+4HCl \rightarrow Cl_2+MnCl_2+2H_2O$$

Chlorine, when combined with hydrogen, has a valence of minus 1. Assuming the valence of chlorine is zero in an uncombined state, upon liberation it has become oxidized. In a similar fashion the valence of manganese in manganese dioxide, MnO_2, which is the oxidizing agent, is plus 4, while in manganous chloride, $MnCl_2$, it is plus 2; during the reaction its valence has been reduced. Whenever an element loses positive valence it is said to be *reduced*.

This gives a broader conception of the terms "oxidation" and "reduction" and it will be found that this idea is a very convenient one to use. For example, in the oxidation of sulfur the valence of sulfur changes from zero to plus 4; therefore, it is oxidized; the valence of oxygen changes from zero to minus 2 so it is reduced. In the oxidation of hydrochloric acid the valence of chlorine changes from minus 1 to zero; hence, it is oxidized; the valence of manganese changes from plus 4 to plus 2, the element undergoing reduction.

In the equations for these reactions both oxidation and reduction occur and in every case where one element undergoes oxidation some other element is reduced. In observing these two equations it will be noted that the gain and loss of valence are equal; one atom of sulfur gains 4 while each atom of oxygen loses 2. One atom of manganese loses 2 while each atom of chlorine gains 1. In every case of oxidation and reduction the total gain in valence is equal to the total loss.

Balancing oxidation and reduction equations.—If the products of a reaction involving a change in valence are known, the coefficients required to balance an equation can be determined by the following rules:

1. Write the reactants and their products, as determined by the simple rules discussed under hydrogen, in the form of an unbalanced equation.
2. Select the elements which show a change of valence and indicate the valence of each atom above its symbol.
3. Determine the gain and loss, and what coefficients are required to make the gain and loss equal.
4. Use these coefficients in their proper places and complete the balancing. Usually it is best to leave hydrogen and oxygen until the last and if the quantities of these elements check the equation is completely balanced.

Hydrogen sulfide reacts with ferric chloride, reducing the iron to the ferrous state with the liberation of sulfur and hydrochloric acid, the unbalanced equation being: $FeCl_3+H_2S \rightarrow FeCl_2+S+HCl$. In changing valence each atom of iron loses 1 valence while each atom of sulfur gains 2; therefore, to balance the equation, there must be twice as many molecules of $FeCl_3$ as there are of H_2S. This leaves two atoms of hydrogen and two atoms of chlorine which unite to form 2 molecules of hydrochloric acid, and the balanced equation becomes:

$$2FeCl_3+H_2S \rightarrow 2FeCl_2+S+2HCl$$

Another example is the reaction between potassium permanganate and hydrochloric acid, in which free chlorine is liberated. Potassium permanganate being the oxidizing agent it appears probable that the resulting products will be free chlorine, water, and a chloride of each of the two metals, potassium and manganese. The unbalanced equation in this reaction will then be:

$$KMnO_4+HCl \rightarrow KCl+MnCl_2+H_2O+Cl$$

The elements in this equation which show a change of valence are manganese and chlorine. In the compound $KMnO_4$ manganese has a valence of positive 7 which, added to the valence of positive 1 of potassium, gives 8 positive valences to exactly balance the 8 negative valences of the 4 atoms of oxygen and make the compound neutral. As, in the compound $MnCl_2$ manganese must have a valence of positive 2 to balance the valence of negative 2 of chlorine, it is evident that manganese has lost 5 valences. In this reaction free chlorine is liberated as a gas. In this form chlorine can neutralize 2 positive valences and, although it is in an uncombined state, in order to work out the equation it is

considered as having a negative valence of 2, and therefore the chlorine liberated as a gas may be said to have gained 1 valence over what it had in the compound HCl. The valence of the chlorine in the chlorides of the metals remains unchanged and need not be considered. To balance this loss and gain of valences there must be 5 atoms of chlorine liberated for every molecule of $KMnO_4$ used, but as the free chlorine is expressed in its molecular form Cl_2, to liberate $5Cl_2$ (10 atoms of chlorine) it will therefore be necessary to use 2 molecules of $KMnO_4$. Using 2 molecules of $KMnO_4$ increases the number of atoms of oxygen in the oxidizing agent from 4 to 8 which have 16 negative valences that will require 16 positive hydrogen valences for balancing. Consequently 16 molecules of the compound HCl are needed to react with 2 molecules of the compound $KMnO_4$ and the left side of the equation becomes $2KMnO_4+16HCl$. By working out this part of the equation so that the products previously mentioned are represented in the other part it will be found that the complete equation for the reaction is:

$$2KMnO_4+16HCl \rightarrow 2KCl+2MnCl_2+8H_2O+5Cl_2$$

and examination shows that each side of the equation balances the other.

It might be thought that in this reaction free oxygen would escape but it does not for as fast as it is liberated it is used in oxidizing hydrochloric acid to form water and chlorine.

Oxidation and reduction may take place simultaneously in a reaction, an example being in the preparation of sulfuric acid from sulfur and nitric acid, when sulfur is oxidized by the oxygen in nitric acid and the nitrogen in nitric acid is reduced to nitric oxide. The unbalanced equation of this reaction is:

$$S+HNO_3 \rightarrow H_2SO_4+NO$$

In this equation sulfur, as an uncombined element, has a valence of zero while in the compound H_2SO_4 it must have a positive valence of 6 as that is the number obtained by substracting the positive valence of 2 for hydrogen from the negative valence of 8 possessed by the 4 atoms of oxygen, and sulfur therefore has gained 6 valences. In the compound HNO_3 nitrogen must have a positive valence of 5 as that is the number obtained by subtracting the positive valence of 1 hydrogen from the negative valence of 6 possessed by the 3 atoms of oxygen, while in the compound NO it must have a positive valence of 2 to balance the negative valence of 2 of oxygen, and nitrogen therefore has lost 3 valences. Consequently, to balance the gain and loss of valences, there is required twice as much nitrogen as sulfur, and the balanced equation therefore is:

$$S+2HNO_3 \rightarrow H_2SO_4+2NO$$

It must always be remembered that oxidation and reduction bring about changes of valence and that oxidation leads to an increase and reduction to a decrease of positive valence.

THE SULFUR FAMILY.—The elements usually considered as members of this family are sulfur, selenium and tellurium, between which there is such close family resemblance that only sulfur will be discussed with any detail. Reference to the Periodic Table will show that with these elements in Group VI is the element oxygen from which it naturally would be expected that they all exhibit certain similarities in properties and might be considered as the oxygen family of elements. Certain properties of all are similar but others are in reverse order, and it is therefore customary to study oxygen singly and the others as the sulfur family.

SULFUR.—Symbol: S; Atomic number: 16; Atomic weight: 32.06; Valence: II, IV, VI; Molecular formula: S_8, S_6, S_2, or S, depending upon temperature, S_8 or S being used most commonly.

Occurrence.—Sulfur is the "brimstone" of the Bible and is found uncombined in nearly all volcanic regions. Sicily and Louisiana are the chief commercial sources. In the combined state, sulfur is found in many mineral ores, especially as *glance* (mineral sulfides), and traces of it are found in the cells of animal and plant life. During the process of decay or disintegration this organically combined sulfur is liberated in the form of volatile compounds, especially hydrogen sulfide, which account for their permeating, offensive odor.

Properties.—Sulfur is a pale yellow, tasteless and nearly odorless substance, insoluble in water. It may exist in several allotropic modifications depending upon the temperature and physical forces to which it is subjected. These forms are crystalline, amorphous, and liquid. At ordinary temperatures sulfur is relatively inactive, but upon the application of heat it combines with nearly all the metals to form sulfides. Many nonmentals combine with sulfur, as chlorine, bromine, hydrogen, etc. Sulfur burns with a pale bluish flame and when heated with oxidizing reagents, it is converted into sulfuric acid. Caustic alkalies dissolve it to form a mixture of alkali sulfides and thiosulfate.

Sulfur is used in large quantities for the preparation of sulfuric acid, sulfur dioxide for bleaching purposes, and vulcanized rubber. In medicine it is used externally and to some extent internally. Sulfur is obtained from its ores by melting, and from subterranean deposits by the application of hot water and air under pressure. Purification of the impure sulfur is carried out by sublimation.

Hydrogen sulfide, H_2S, is a heavy, colorless gas with a nauseating odor resembling that of rotten eggs. It is poisonous, and prolonged inhalation of its fumes will cause distressing symptoms and even death in dilutions as weak as 1 to 200. It is a powerful reducing agent and is extensively employed in chemical analysis to precipitate many metals from their salts as sulfides:

$$PbO + H_2S \rightarrow PbS\downarrow + H_2O$$

This gas is extremely inflammable and burns with a pale blue flame. The products of its combustion are water and sulfur dioxide, or sulfur, if combustion is rapid. In aqueous solution it undergoes slow oxidation from contact with air, sulfur being precipitated. Boiled (air free) water should be used in preparing its solution, which is to be kept in well-closed containers away from light. It is decomposed by many oxidizing agents. Chlorine, bromine, and iodine combine readily with its hydrogen, precipitating sulfur:

$$H_2S + Cl_2 \rightarrow 2HCl + S\downarrow$$

When solutions of metallic salts are treated with hydrogen sulfide various metallic sulfides of characteristic color and solubility are formed. These sulfides are divided into two large groups:

1. Sulfides insoluble in dilute acid (CuS, HgS, As_2S_3, etc.);
2. Sulfides insoluble in neutral or alkaline solutions, but soluble in dilute acids (NiS, MnS, ZnS, etc.).

By application of these factors (solution or precipitation with an acid or base) and separation by filtration, the sulfides of most metals can be isolated, then identified, and their percentage estimated. This method is useful in detecting lead in the urine, and arsenic or mercury in the stomach, liver, and kidneys.

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Hydrogen sulfide is formed when a stream of hydrogen is passed over boiling sulfur. In the laboratory it is prepared by the action of hydrochloric acid upon a metallic sulfide in the presence of water:

$$FeS + 2HCl \rightarrow FeCl_2 + H_2S \uparrow$$

A generator similar to the one illustrated in figure 152 may be satisfactorily used. In the generator (A) is placed some ferrous sulfide covered with water and to it from time to time is added hydrochloric acid, sufficient to keep up evolution of the gas. The gas is readily evolved without the application of heat, and may be used directly or passed through a wash-bottle.

Sulfur dioxide, SO_2, is a colorless gas with a peculiar suffocating odor; it is easily liquefied at ordinary temperatures. It is a strong reducing agent, weakly acid in aqueous solution, and reacts with water to form sulfurous acid:

$$SO_2 + H_2O \leftrightarrows H_2SO_3$$

It also reacts with hydrogen sulfide, oxygen, and chlorine. Sulfur dioxide is the gas used in many mechanical refrigerators; sulfuric acid is manufactured from it, and it is employed as a bleaching and fumigating agent. It may be prepared by burning sulfur or metallic sulfides.

Sulfuric acid, H_2SO_4, is an oily, colorless liquid with a density of 1.838 at 15° C. It mixes in all proportions with water, evolving much heat, and therefore should always be poured slowly into water to avoid spattering. Sulfuric acid is a powerful oxidizing and dehydrating agent, charring dry wood, sugar, and other organic substances. It combines with nearly all the metals to form sulfates:

$$Cu + H_2SO_4 \rightarrow CuSO_4 + H_2 \uparrow$$

It is prepared on a commercial scale by two processes:

1. The Lead Chamber Process in which sulfur dioxide mixed with air is oxidized to sulfur trioxide (SO_3) by nitric acid vapors in a lead lined chamber, enough water being present to form sulfuric acid:

$$2SO_2 + 2HNO_3 + H_2O \rightarrow 2H_2SO_4 + NO + NO_2$$

2. The Contact Process in which sulfur dioxide mixed with air is passed over a catalyst, such as finely divided platinum or ferric oxide, at 400° C. and oxidized to sulfur trioxide. The sulfur trioxide is allowed to bubble through a mixture of sulfuric acid and water where it combines with the water to form more sulfuric acid:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Sulfuric acid is used in the manufacture of nitro-glycerin, smokeless powder, hydrochloric acid from sodium chloride and nitric acid from sodium nitrate.

SELENIUM and TELLURIUM, as well as their compounds, are very similar to sulfur and its compounds. Selenium is valuable chiefly because its electrical conductivity is greatly increased while exposed to light, making it useful in many automatic devices which are controlled by light; its molecular formula is Se_8.

THE NITROGEN FAMILY.—This family consists of nitrogen, phosphorus, arsenic, antimony, and bismuth. These elements show a graded difference in their physical and chemical properties. The difference is more pronounced between these elements than those of the halogen group. In their chemical properties the nonmetallic properties gradually give way to the metallic with increase in atomic weight.

NITROGEN.—Symbol: N; Atomic number: 7; Atomic weight: 14.008; Valence: III, V; Molecular formula: N_2.

Occurrence.—In the free state nitrogen constitutes about 4/5 of the atmosphere. It is found in large quantities combined with sodium and oxygen in *Chili saltpetre.* Combined with hydrogen in the form of ammonia, it is a by-product of the destructive distillation of coal. Animal and vegetable substances contain nitrogen which is given off as ammonia during the process of decomposition.

Properties.—Nitrogen is a colorless, odorless, and tasteless gas. It is neither combustible nor capable of supporting combustion. In the free state it is inactive, but nearly all nitrogen compounds are very active, the alkaloids and cyanides being quite toxic to animal tissues. The preparation of its compounds is almost always performed by indirect means.

Isolation.—Nitrogen may be prepared by removing the oxygen from the air, or by chemical means through the reaction of potassium dichromate on ammonium chloride:

$$K_2Cr_2O_7+2NH_4Cl \rightarrow Cr_2O_3+2KCl+4H_2O+N_2$$

Ammonia, NH_3, is a colorless gas with a pungent suffocating odor and caustic taste, quite soluble in water. It is alkaline to litmus and combines with acids to form ammonium salts. The formula NH_4 (ammonium) represents a hypothetical compound that has many properties in common with potassium and sodium. Ammonia gas, NH_3, combines with water to form a weak hydroxide, NH_4OH, the equation being: $NH_3+H_2O \rightarrow NH_4OH$. Ammonia is used chiefly in mechanical refrigeration and in the production of nitric acid. In dilute aqueous solutions it is an effective cleaning fluid.

Nitrous oxide, N_2O, is a colorless gas with a faint peculiar odor and sweetish taste. It supports the combustion of many substances almost as actively as oxygen. A mixture of nitrous oxide and hydrogen explodes with violence when ignited. This gas is used extensively in minor surgery and dentistry when a short anæsthesia is desired. The anæsthetic effect is controlled by inhalation of the gas mixed with oxygen. Aside from its anæsthetic effect, it is physiologically inert. The usual method of preparation is by heating ammonium nitrate at a temperature of below 250° C., decomposing it into nitrous oxide and water:

$$NH_4NO_3+\text{Heat} \rightarrow N_2O+2H_2O$$

Nitric oxide, NO, is a colorless gas which produces reddish colored fumes upon contact with the oxygen in the air, forming nitrogen dioxide:

$$2NO+O_2 \rightarrow 2NO_2$$

Nitric oxide will not burn, but supports combustion at high temperatures. It is used in the manufacture of nitric acid, and sulfuric acid by the Lead Chamber Process.

Nitric acid (aqua fortis), HNO_3, is not found in Nature in the free state, but the nitrate radical (NO_3) in nitric acid, is found combined with potassium, sodium, calcium, and magnesium in the nitrates of those elements, the largest known deposits of nitrates being the sodium nitrate beds of the rainless districts on the coast of Chile. Nitric acid is a colorless, fuming, very corrosive liquid. When exposed to light it assumes a yellow to orange color due to slight decomposition, with the formation of nitrogen dioxide (NO_2).

Due to its unstable character nitric acid acts as a powerful oxidizing agent. Through action that occurs within itself nitric acid frequently is reduced, forming the lower nitrogen oxides NO, N_2O_3, and NO_2. As a result of such energetic properties, it dissolves nearly all the metals, with the exception of

gold and platinum, forming nitrates, or converting them into acids and insoluble oxides according to their nature:

$$3Hg+8HNO_3 \rightarrow 3Hg(NO_3)_2+4H_2O+2NO$$

Due to the oxidizing action of nitric acid upon hydrochloric acid, chlorine is liberated in its most active (nascent) form. This atomic chlorine reacts vigorously with metals and is useful in combining with those metals which are below hydrogen in the Electrochemical Series, especially gold and platinum. Such a mixture, containing 1 part of nitric acid to 3 parts of hydrochloric acid, is known as nitrohydrochloric acid (aqua regia).

Many organic substances, such as turpentine, burst into flame upon contact with nitric acid, while others merely turn yellow. Substances like cotton, benzene and glycerin undergo a process of nitration when treated with the concentrated acid (nitro-cellulose, nitro-benzene, nitro-glycerin).

In dealing with nitric acid it must be clearly remembered that it has two actions, that of an acid and that of an oxidizing agent.

Nitric acid containing nitrogen tetroxide, which imparts an orange color to the liquid, is known as fuming nitric acid. This substance is prepared by the addition of paraformaldehyde or a little starch to the colorless acid and heating the solution. This form of nitric acid is more energetic in its oxidizing power than the colorless variety.

Nitric acid has extensive commercial applications, being employed in the manufacture of sulfuric acid, explosives, artificial silks, and many other important commodities. It is used as a solvent in the refining of precious metals.

Nitric acid is produced from sodium and potassium nitrate by heating them in a retort with sulfuric acid:

$$H_2SO_4+2NaNO_3 \rightarrow Na_2SO_4+2HNO_3.$$

The nitric acid distills over, is concentrated, and then purified.

Nitrates are monobasic salts prepared by dissolving a metal or its oxide in nitric acid. Nearly all the nitrates are soluble in water with the exception of a few basic salts. The alkali nitrates are employed in dry oxidation.

PHOSPHORUS.—Symbol: P; Atomic number: 15; Atomic weight: 31.02; Valence: III, V; Molecular formula: P_4.

Occurrence.—Phosphorus is never found in the free state, but chiefly as tri-calcium phosphate, which is the principal constituent of bones as well as of the minerals, *apatite*, $CaF_2.3Ca_3(PO_4)_2$ and *phosphorite*, $Ca_3(PO_4)_2$. Both of these minerals are used extensively in commercial fertilizers. Phosphorus is also found distributed in comparatively small quantities in plant and animal tissues, in the soil and in sea-water.

Properties.—Phosphorus exists in several allotropic forms, yellow and red phosphorus being the most important. The yellow variety is a translucent, wax-like solid which is soft enough to be cut with a knife at ordinary temperatures. It is insoluble in water but extremely soluble in carbon disulfide, 1 Gm. dissolving in 0.9 cc. In handling, phosphorus must be kept under water because it is a very inflammable substance, igniting spontaneously in the air at 40° C. The phosphorescence visible in the dark upon exposure to air, appears to be due to slow oxidation.

Yellow phosphorus possesses a great affinity toward many elements, uniting directly with nearly all except nitrogen, the inert gases, carbon and the noble metals. With bromine and sulfur it reacts violently. Due to its great affinity for oxygen it is a powerful reducing agent. It decomposes nitric acid with

explosive violence, and reduces salts of some metals, as mercury, gold and copper, to metals and phosphides.

Red, or amorphous phosphorus, an allotropic form, possesses essentially different properties from the yellow variety, being a dark red to yellowish brown, inodorous powder which is insoluble in carbon disulfide and all other solvents. It does not phosphoresce and is stable in air. Red phosphorus is prepared by heating the yellow variety to 300° C. in airtight chambers. After the conversion, the resulting product is treated with carbon disulfide to remove any remnants of yellow phosphorus. The chief use of this variety is in the manufacture of safety matches. It is also extensively employed in organic synthesis.

The red variety is not poisonous, whereas the yellow variety produces burning in the stomach, vomiting and convulsions. The inhalation of the vapors, for any length of time, causes necrosis of the bones and liver.

Isolation.—Phosphorus is obtained from bone ash by treatment with silica and coke in the "continuous acting" electric furnace process:

$$2Ca_3(PO_4)_2+6SiO_2+10C \rightarrow P_4+6CaSiO_3+10CO\uparrow$$

Phosphorus combines readily with the halogens to form compounds of the types PR_3 and PR_5, R representing any of these elements.

Four oxides and eight acids of phosphorus are known:

Oxides		Acids	
Phosphorus protoxide	P_2O	Hypophosphorous acid	H_3PO_2
Phosphorus trioxide	P_4O_6	Orthophosphorus acid	H_3PO_3
Phosphorus tetroxide	P_2O_4	Metaphosphorous acid	HPO_2
Phosphorus pentoxide	P_2O_5	Orthophosphoric acid	H_3PO_4
		Metaphosphoric acid	HPO_3
		Pyrophosphorous acid	$H_4P_2O_5$
		Pyrophosphoric acid	$H_4P_2O_7$
		Hypophosphoric acid	$H_4P_2O_6$

The meta- and pyro-phosphoric acids are anhydrides of orthophosphoric acid and may be considered derivatives of phosphoric oxide plus varying amounts of water:

$$P_2O_5+H_2O \rightarrow 2HPO_3$$

$$P_2O_5+2H_2O \rightarrow H_4P_2O_7$$

$$P_2O_5+3H_2O \rightarrow 2H_3PO_4$$

Phosphorus Pentoxide, P_2O_5, is a bulky, white, amorphous, or crystalline powder, prepared by burning phosphorus in iron cylinders supplied with a current of dry air and purified by subsequent sublimation in a current of oxygen to free it from *ous* oxides. Phosphorus pentoxide has a powerful affinity for water, producing a hissing sound when thrown into it. Because of this property it is used as a desiccating agent, especially for drying gases.

Orthophosphoric acid (*anhydrous*), H_3PO_4, occurs in rhombic prisms which, on exposure to moist air or upon addition to water, deliquesce to a thick syrupy liquid. The Acid Phosphoricum, U. S. P., contains not less than 85 per cent, nor more than 88 per cent of H_3PO_4.

When heated from 200° C. to 215° C., orthophosphoric acid is gradually converted into pyrophosphoric acid $H_4P_2O_7$. When heated above 400° C. it is completely converted into metaphosphoric acid, HPO_3.

This acid forms 3 classes of salts depending upon the number of hydrogen atoms replaced by a metal:

Primary phosphate	NaH_2PO_4
Secondary phosphate	Na_2HPO_4
Tertiary phosphate	Na_3PO_4

ARSENIC.—Symbol: As; Atomic number: 33; Atomic weight: 74.91; Valence: III, V; Molecular formula: As_4.

Occurrence.—Arsenic is widely distributed in nature. In the free state it is usually found in crystals, while in the combined state it is abundantly distributed as sulfides or metallic arsenides. Small quantities of arsenic are found in many mineral waters and in sea-water.

Properties.—Arsenic usually occurs in the form of a steel-gray, brittle, crystalline mass. It exhibits two allotropic modifications, crystalline and amorphous. The latter form is black and when heated to 360° C. reverts to the crystalline form.

Isolation.—Arsenic is obtained by heating arsenical pyrites out of contact with air. The arsenic sublimes, leaving the iron as a sulfide.

$$4FeAsS + Heat \rightarrow As_4 + 4FeS$$

Arsenic forms compounds analogous to those of nitrogen and phosphorus, arsenic trioxide being one of the most important.

Arsenic trioxide, or *arsenious oxide*, As_2O_3, is a white amorphous or crystalline powder having three allotropic forms, each variety depending upon its crystal formation. It is readily oxidized to arsenic oxide, hence, it is employed as a reducing agent. With the alkali hydroxides it readily forms salts.

Arsenic trioxide is a powerful irritant poison, the antidote being the Magma Ferri Hydroxidi of the U. S. P. which acts as a colloid, absorbing the arsenic and rendering it innocuous.

In small doses arsenic trioxide and other arsenical compounds are widely employed in medicine. It is also used in the preparation of dyes.

ANTIMONY.—Symbol: Sb; Atomic number: 51; Atomic weight: 121.76; Valence: III, V.

Occurrence.—The chief source of antimony is the antimony *glance* or stibnite, Sb_2S_3. Native antimony is usually accompanied by arsenic.

Properties.—Antimony is a silver-white, lustrous metal, more basic than arsenic, but less so than bismuth. It possesses both metallic and nonmetallic properties, combining with oxygen and the halogens. Strong nitric acid and sulfuric acid react with it to form the nitrate and sulfate, but with dilute acids no reaction occurs. In combination with other metals it composes some of the more common alloys. Aside from the fact that some of its compounds, which are similar to those of arsenic, are used in medicine, they have very little practical value.

BISMUTH.—Symbol: Bi; Atomic number: 83; Atomic weight: 209.00; Valence: III, V.

Occurrence.—The commercial sources of bismuth are not numerous. Both the metal and its ores are generally disseminated through rock. Bolivia is now the chief source of supply.

Properties.—Bismuth is a hard, brittle, lustrous, white metal of crystalline structure, being isomorphous with arsenic and antimony. It is chemically inactive at ordinary temperatures, but at elevated temperatures it is converted into the oxide:

$$4Bi + 3O_2 \rightarrow 2Bi_2O_3$$

It is acted upon by hot nitric and sulfuric acids. Combination with the halogens takes place slowly.

The insoluble salts are employed in medicine, while metallic bismuth is a valuable constituent of various alloys. Both bismuth and arsenic are extensively used as spirochæticidal agents in the treatment of syphilis.

CARBON AND SILICON.—These are the first two elements in Group IV of the Periodic Table and are the only ones of the two families in this group that will be here discussed.

Carbon is the essential element in the organic world and it has far more compounds than any other element due to the fact that its atoms possess the power of combining with each other and thus forming compounds that are very complex in character. The organic compounds of carbon possess certain well-defined characteristics, thousands of them are known, and many can be prepared by synthesis from the elements. So numerous are the compounds of carbon that most of them are considered and studied as a special branch of the science of chemistry known as *organic chemistry*, which later will be briefly discussed.

Silicon occupies in the mineral or inorganic world the same position that carbon does in the organic, and is considered as the most important element in that world.

CARBON.—Symbol: C: Atomic number: 6; Atomic weight: 12.01; Valence: IV.

Occurrence.—Carbon occurs in Nature in three allotropic forms, two of which are crystalline and the third amorphous. The two crystalline forms are the diamond and graphite. Amorphous carbon occurs naturally in the various forms of coal and many amorphous forms may be prepared, as coke, charcoal, boneblack, lampblack, and soot. Combined with hydrogen and other elements it comprises all organic material and their by-products. Carbon and its compounds are found widely distributed in the Earth as coal and oil.

Properties.—Carbon is an odorless, tasteless, black solid except in the diamond where it is colorless. Different forms vary in hardness and electrical conductivity, intense heat converting them all to the graphite modification. It has great absorbing powers which are employed in the refining of sugar and the construction of gas masks.

Carbon when heated unites readily with oxygen, hydrogen and some of the metals. As coke it is a reducing agent used in blast furnaces. It is an amphoteric element exhibiting both metallic and nonmetallic properties. Carbon stands alone among the elements in that it is capable of combining with itself to form long chains of carbon atoms. Silicon possesses this property to some degree but the length of the chain is limited.

Carbon dioxide, CO_2 is a colorless, odorless, heavy gas, soluble in an equal volume of water at 15° C. but much more so under pressure. It is a product of the oxidation of all organic matter, being formed in both combustion and decay, and of many fermentation processes, and is exhaled from the lungs of all animals in respiration. It will not support combustion nor is it combustible. Metallic oxides unite with it to form carbonates:

$$CaO + CO_2 \rightarrow CaCO_3$$

Carbon dioxide reacts with water to form the hypothetical carbonic acid ($H_2O + CO_2 \leftrightarrows H_2CO_3$) which has never been isolated because upon liberation it immediately reverts to carbon dioxide and water. In solution, it reacts with bases to produce carbonates, or bicarbonates if an excess of acid is present. Carbon dioxide is used in fire extinguishers, leavening agents, and in the manufacture of carbonated beverages.

Carbon monoxide, CO, is a colorless, poisonous, almost odorless gas formed from the incomplete combustion of carbon, $2C+O_2 \rightarrow 2CO$. It escapes from stoves too closely damped, kerosene heaters, automobile exhausts, and is a constituent of illuminating gas. Dilutions of 1 in 800 are fatal if breathed for one-half hour. It is a good reducing agent, extracting oxygen from hot metallic oxides.

Phosgene, $COCl_2$, is a gas used in chemical warfare.

Carbon tetrachloride, CCl_4, is valuable as a solvent and fire extinguisher.

Carbon disulfide, CS_2, is a highly inflammable liquid and is of value as a solvent of rubber, sulfur and other substances. It is also an efficient exterminator of vermin.

Cyanogen, C_2N_2, is a very poisonous gas from which is derived hydrocyanic acid, HCN ("prussic acid"), a colorless, extremely poisonous, volatile liquid characterized by its almond-like odor. Hydrocyanic acid reacts with most of the metals to form cyanides and cyanates. It is used in the fumigation of ships.

SILICON.—Symbol: Si; Atomic number: 14; Atomic weight: 28.06; Valence: IV.

Occurrence.—Silicon does not occur in the free state, is not found in the air either as an element or a compound, and is not present to any considerable extent in water. Except for oxygen, it is the commonest element, composing one-fourth of the Earth's crust. It is found in quartz, sand, and sandstone. Clay and all common rocks, except limestone and dolomite, are silicates.

Properties.—Silicon occurs in two allotropic forms, amorphous silicon which is a brown powder, and crystalline silicon which is obtained as hard, black, hexagonal crystals. It burns in oxygen and combines with the halogens at suitable temperatures to form gases. It is insoluble in acids, but dissolves readily in sodium hydroxide, displacing hydrogen from the solution:

$$4NaOH+Si \rightarrow Na_4SiO_4+2H_2$$

Silicon is capable of uniting with itself in a manner similar to that of the carbon atoms, but whereas the carbon atom is capable of building an almost limitless number of complex molecules, the limit of stability for the silicon chain is Si_6H_{14}. It is of importance in the manufacture of glass. The element is isolated by reducing the oxide with powdered magnesium or aluminum:

$$SiO_2+2Mg \rightarrow 2MgO+Si, \text{ or}$$
$$3SiO_2+4Al \rightarrow 3Si+2Al_2O_3$$

The metals.

THE ALKALI METALS.—The elements of the alkali group constitute a family in Group I of the Periodic Table and have a valence of I. They are called alkali metals because the most familiar members of the family, sodium and potassium, are found in compounds that have long been known as alkalis. The members of this family possess certain properties in common in that they are light, soft metals with a low melting point, silvery-white in appearance, and of a bright metallic luster when pure. They oxidize in air and energetically decompose water, with the evolution of hydrogen, to form hydroxides of a strong alkaline reaction. They occupy places near the top of the electrochemical series which shows they are very active metals, do not occur free in Nature, and their compounds with very few exceptions, are white solids soluble in water. Sodium and potassium are the most important members of the family.

SODIUM.—*Symbol*: Na; Atomic number: 11; Atomic weight: 22.997; Valence: I.

Occurrence.—Sodium, like all other alkali metals, is not found in Nature in the free state but in combination with other elements in which form it is widely distributed throughout the world. Combined with chlorine it forms the salt of sea-water and rock-salt mines.

Properties.—Sodium is a silvery-white metal of waxy consistency at ordinary temperatures prepared in various ways. It decomposes water, reacts with acids forming the corresponding salts and liberating hydrogen, and combines directly with the halogens:

$$2Na + Cl_2 \rightarrow 2NaCl$$

and has a great affinity for oxygen:

$$2Na + O_2 \rightarrow Na_2O_2$$

It is a good reducing agent, displacing hydrogen from water and alcohol:

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

When heated in the Bunsen flame it, as well as most of its compounds, volatilizes and colors the flame yellow.

Sodium and its compounds are of great importance.

Isolation.—Sodium is isolated by the electrolysis of fused sodium hydroxide in Castner cells.

Sodium chloride, NaCl, is found in rock-salt deposits, salt lakes, and sea-water. It occurs as transparent cubical crystals and as a white crystalline powder. When calcium or magnesium is present it is more or less hygroscopic, but in the pure state it does not possess this property. It is used in the preparation of other sodium compounds and reacts with nonvolatile acids to form hydrochloric acid:

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

It is the principal condiment used for seasoning food and also acts as a food preservative. Mined in the comparatively pure state it is sent into commerce without further purification. Large quantities are obtained from the evaporation of sea-water.

Sodium hydroxide, NaOH, is a white, solid, hard mass that is deliquescent in the presence of moist air. It is extremely basic to indicators and is a strong caustic. It has many uses, being employed in large quantities in the manufacture of soap and in the neutralization of acids to form their sodium salts. It may be prepared by the electrolysis of sodium chloride.

Sodium bicarbonate, $NaHCO_3$, is a white opaque powder, permanent in air under ordinary circumstances but decomposing slowly in moist air. It has a mild alkaline reaction which increases upon long standing due to the loss of carbon dioxide and subsequent formation of sodium carbonate. It is the main constituent of most baking powders and has considerable use in the textile industry. In medicine it is used as an antacid. Nearly all the sodium bicarbonate of commerce is prepared by the Solvay Process which is known as the ammonia-soda process, the reaction being:

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

Sodium carbonate, Na_2CO_3, closely resembles sodium bicarbonate except that its alkaline reaction is stronger due to its greater hydrolysis in water.

It is prepared by heating sodium bicarbonate:

$$2NaHCO_3 + Heat \rightarrow Na_2CO_3 + CO_2 + H_2O$$

POTASSIUM, LITHIUM, RUBIDIUM, and CÆSIUM are similar to sodium in their properties.

THE ALKALINE EARTH METALS.—The metals of this group are grayish-white in color, of a bright metallic luster, malleable and ductile. They belong to Group II of the Periodic Table, have a valence of II, are very active, tarnish quickly in air, and react with water to form hydroxides, with hydrogen being liberated. The halogens and nitrogen combine with them directly. The hydroxides of these metals increase in solubility with the increase in atomic weight of the metals; the sulfates decrease in solubility with the increase in atomic weight.

MAGNESIUM.—Symbol: Mg; Atomic number: 12; Atomic weight: 24.32; Valence: II.

Occurrence.—This element is not found in the uncombined state in Nature, however, its compounds are widely distributed.

Properties.—Magnesium is a silvery-white, highly lustrous metal. It is stable in dry air but in the presence of moisture gradually becomes covered with a film of magnesium oxide. Heated in air it ignites and burns with a blinding white light which is especially rich in actinic rays. It is employed in photography as a flashlight powder, and in the manufacture of fireworks and light-weight alloys. It decomposes slightly at 100° C. or over in air with the formation of magnesium oxide (MgO) and some magnesium nitride (Mg_3N_2).

Isolation.—Magnesium is isolated by the electrolysis of the fused double chloride, $MgCl_2.KCl.6H_2O$ (carnallite).

Magnesium chloride, $MgCl_2$, is found in sea water and certain salt deposits. It is very deliquescent in air.

Magnesium sulfate, $MgSO_4$, is found along with the chloride in salt deposits; the hydrate, $MgSO_4.7H_2O$, is known as Epsom Salts.

CALCIUM.—Symbol: Ca; Atomic number: 20; Atomic weight: 40.08; Valence: II.

Occurrence.—The compounds of calcium are widely distributed in Nature, the carbonate being the most abundant.

Properties.—Calcium is a tough and malleable silvery-white metal with a bright luster. It resists oxidation in dry air, but in the presence of moisture it quickly becomes covered with the hydroxide which gradually extends throughout the whole mass. It is very active chemically and at high temperatures burns with a brilliant white light.

Isolation.—Calcium is isolated by the electrolysis of the fused chloride.

Calcium carbonate, $CaCO_3$, is found as limestone, marble, and chalk. It is a white transparent solid insoluble in water, but dissolved by most acids with the liberation of CO_2. It is used in the building industries as stone, mortar, plaster, etc.

Calcium oxide, CaO, (lime) is prepared by heating calcium carbonate:

$$CaCO_3 + Heat \rightarrow CaO + CO_2$$

It is a white solid which reacts with water, forming calcium hydroxide and producing considerable heat:

$$CaO + H_2O \rightarrow Ca(OH)_2$$

BERYLLIUM, STRONTIUM, and BARIUM are elements somewhat similar in their properties to magnesium and calcium.

BORON AND ALUMINUM.—Boron and aluminum are the first two elements of Group III in the Periodic Table. None of the other elements in this group are abundant or well known. Boron is a nonmetal; aluminum is a metal. A valence of III is shown by both elements in all their compounds.

Boron more closely resembles silicon than aluminum in its properties.

BORON.—Symbol: B; Atomic number: 5; Atomic weight: 10.82; Valence: III.

Occurrence.—Boron does not occur in the free state but is found combined with oxygen and hydrogen as boric acid and sodium borate, or borax, deposits of the latter being located in California and Nevada in the United States and in Peru and Chile, South America.

Properties.—Boron is an amorphous powder which can be fused to a very hard and brittle mass. It combines slowly with oxygen at 100° C. and at high temperatures burns with a green flame:

$$4B+3O_2 \rightarrow 2B_2O_3$$

The halogens combine with it at high temperatures; nitric acid oxidizes it to boric acid, and the metals combine with it to form borides. There are no important uses of boron.

Isolation.—Boron is isolated by heating boric trioxide with magnesium to redness. The resultant mass is treated with hydrochloric acid and alkalies.

Boric acid, H_3BO_3, occurs in certain volcanic districts, especially in Tuscany where it is obtained by condensing the vapors of hot springs. It may be prepared by treating borax ($Na_2B_4O_7.10H_2O$) with an acid. It is sparingly soluble in water and has weak acidic properties. Its main use is as a mild antiseptic.

ALUMINUM.—Symbol: Al; Atomic number: 13; Atomic weight: 26.97; Valence: III.

Occurrence.—Aluminum composes 7 per cent of the Earth's crust, being the most abundant metal. Due to its chemical activity it is never found in the free state.

Properties.—It is a bluish-white metal of high luster, somewhat malleable and ductile. Water does not act upon it at any temperature. It combines with many of the nonmetals, especially the halogens, and with members of the sulfur family. It reacts with acids:

$$2Al+6HCl \rightarrow 2AlCl_3+3H_2,$$

and soluble bases:

$$2Al+6NaOH \rightarrow 2Na_3AlO_3+3H_2$$

In oxygen it burns with a brilliant light and is used in the manufacture of flashlight bulbs. Most cooking utensils are now made of aluminum. Lightweight alloys are also largely aluminum.

Isolation.—Aluminum is isolated by the electrolysis of bauxite, molten cryolite being used as the solvent.

Aluminum oxide, Al_2O_3, is found in Nature as corundum, and in the finer crystals as ruby and sapphire, colored red or blue, due to traces of metallic oxides.

RARE EARTHS.—These elements are trivalent and when oxidized are of the general formula R_2O_3. The hydroxides are white amorphous precipitates which do not dissolve in alkali hydroxides. With alkali sulfates they form double salts.

COPPER.—Symbol: Cu; Atomic number: 29; Atomic weight, 63.57; Valence: I, II.

Occurrence.—Metallic copper is found in the free state and in combination with other elements. It is obtained from its ores by smelting.

Properties.—Copper is a lustrous, malleable, and ductile metal with a peculiar reddish color. Next to silver it is the best conductor of electric current and its most important use is as "electric wire". It forms two series of compounds, those in which the valence is I (cupr*ous*), and those in which the valence is II (cupr*ic*).

Copper sulfate, $CuSO_4$, is prepared by the action of sulfuric acid on copper. The crystalline form has a bluish color. When the crystals are heated they lose their color and become a white, amorphous powder which reverts to the blue crystalline form upon the readdition of water. It is used in copper refining, electroplating and calico printing. It is occasionally used in lakes and reservoirs to kill organisms such as algæ.

ZINC.—Symbol: Zn; Atomic number: 30; Atomic weight: 65.38; Valence: II.

Occurrence.—Zinc occurs chiefly as a sulfide or zinc blende, and as a carbonate. The pure metal is obtained by roasting and refining.

Properties.—Zinc is a bluish-white metal, malleable and ductile between 100° C. and 150° C. and is used in the manufacture of galvanized iron, bronze, brass, German silver, and other alloys. Zinc tarnishes readily but the formation of a basic carbonate prevents its oxidation. In a flame it burns with a blue color. Acids act upon it to form salts. Soluble bases combine with it to form zincates:

$$Zn+2HCl \rightarrow ZnCl_2+H_2;$$
$$Zn+2NaOH \rightarrow Na_2ZnO_2+H_2$$

Zinc oxide, ZnO, is made by burning zinc vapors in oxygen. It is a white powder used in paints.

Zinc sulfate, $ZnSO_4$, is used in printing, dyeing cloth, and in medicine as an astringent. All zinc compounds are poisonous.

MERCURY.—Symbol: Hg; Atomic number: 80; Atomic weight: 200.61; Valence: I, II.

Occurrence.—Mercury is found in the native state as minute globules disseminated throughout its ores. The most abundant mercury ore is cinnabar, (mercuric sulfide, HgS).

Properties.—At ordinary temperatures mercury is a liquid, silvery-white, lustrous metal. When cooled to minus 38.8° C. it forms a malleable, ductile, and crystalline solid. It is insoluble in water or other solvents. At ordinary temperatures hydrochloric and sulfuric acids have no effect upon it, but when boiled with the latter it slowly dissolves with the evolution of sulfur dioxide. Nitric acid dissolves it rapidly, forming mercur*ous* nitrate if the mercury is in excess, and mercur*ic* nitrate if the nitric acid is in excess:

$$6Hg+8HNO_3 \rightarrow 6HgNO_3+2NO+4H_2O;$$
$$3Hg+8HNO_3 \rightarrow 3Hg(NO_3)_2+2NO+4H_2O$$

With oxygen it combines to form an oxide; this action is reversible:

$$2Hg+O_2 \leftrightarrows 2HgO$$

The halogens combine with mercury at ordinary temperatures. Many metals, such as gold and silver, form an amalgam with mercury.

Mercuric chloride, $HgCl_2$, is a white crystalline salt, soluble in water, made by heating a mixture of mercuric sulfate and sodium chloride. It is a powerful antiseptic and a dangerous irritant poison.

Mercurous chloride, HgCl, is a white powder prepared by heating mercuric chloride with mercury. It has extensive use in medicine.

THE TIN GROUP.—Germanium, tin, and lead, along with carbon and silicon form a group in which the elements exhibit a valence of II and IV. A subgroup related to these are titanium, zirconium, and thorium.

TIN.—Symbol: Sn; Atomic number: 50; Atomic weight: 118.70; Valence: II, IV.

Occurrence.—The most important tin ore is *cassiterite*, or *tin stone*, SnO_2, found most abundantly in the Malay States, Bolivia, the East Indies, and China.

Properties.—Tin is a white, lustrous metal existing in two allotropic forms, the gray form being brittle and easily crumbled into powder, while the white variety is soft and malleable. It is not affected by air or water at ordinary temperatures, but when strongly heated in a flame it burns with an intense white light to its oxide, SnO_2. Tin reacts with the strong acids and hot concentrated solutions of the strong alkalies, but is not affected by organic acids and weak alkalies. Due to its resistance to many chemical solutions it is used to plate copper and iron vessels. Most of it is used for tin plating cans, and it is a constituent of alloys such as bronze.

Isolation.—Tin is obtained by reducing the oxide, SnO_2, with carbon in a reverberatory furnace. Many of the compounds of tin are used in the dyeing industry.

LEAD—Symbol: Pb; Atomic number: 82; Atomic weight: 207.21; Valence: II, IV.

Occurrence.—The most important and abundant source of lead is the sulfide (galena), PbS, which is widely distributed.

Properties.—Lead is a silvery-grayish metal, soft and malleable, easily cut with a knife, and when drawn across paper it leaves a gray streak. In the presence of air a coating of lead oxide is formed which protects the metal from further oxidation. Cold concentrated hydrochloric and sulfuric acids have but little action on it. When boiled with these acids the chloride and sulfate are formed. With nitric acid it acts readily to form lead nitrate and oxides of nitrogen:

$$3Pb + 8HNO_3 \rightarrow 3Pb(NO_3)_2 + 4H_2O + 2NO$$

Large quantities of lead are used in the plumbing industry and in the manufacture of storage batteries, alloys and paints.

Isolation.—Lead is obtained from its ores by roasting in a current of air to oxidize the sulfide:

$$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$$

The air supply is removed after ⅔ of the ore has been oxidized and then the temperature is raised. This produces metallic lead:

$$PbS + 2PbO \rightarrow 3Pb + SO_2$$

Oxides of lead.—Litharge (PbO), red lead (Pb_3O_4), and lead dioxide (PbO_2) are the important oxides of lead. The first is used in glass manufacture, the second as a paint pigment, and the third in making storage batteries.

Basic lead carbonate, $2PbCO_3.Pb(OH)_2$ (white lead) is prepared by the action of air, carbon dioxide, and acetic acid upon perforated lead plates. It is used as a paint pigment.

THE IRON GROUP.—This group, No. VIII in the Periodic Table, contains iron, nickel, and cobalt. It is distinguished because of the magnetic properties of its members.

IRON.—Symbol: Fe; Atomic number: 26; Atomic weight: 55.84; Valence: II, III.

Occurrence.—Iron occurs free in meteorites, and combined as oxides, carbonates, silicates and sulfides.

Properties.—Pure iron is of a silvery-white appearance. In this state it is too soft for commercial purposes, therefore, small quantities of other elements, such as carbon, silicon and manganese are added to give it hardness. When

iron is combined with small quantities of carbon it is known as steel. Dry air, or water free from carbon dioxide, does not affect iron, while the presence of moisture and carbon dioxide causes the formation of hydrated ferric oxide (rust). Concentrated nitric acid and sulfuric acid have no action upon iron at ordinary temperatures, although when diluted they attack it readily.

Isolation.—Iron, as used in commerce, is obtained by reducing its ores in blast furnaces. Pure iron is isolated by electrolysis or reduction of the pure oxide in a current of hydrogen.

Ferric chloride, $FeCl_3$ is prepared by burning iron wire in chlorine. It is extremely soluble in water and alcohol. Its alcoholic solution is known as Tincture of Ferric Chloride.

Ferrous chloride, $FeCl_2$, is prepared by treating iron with hydrochloric acid, in the absence of air:

$$Fe+2HCl \rightarrow FeCl_2+H_2$$

SILVER AND GOLD.—Silver and gold are known as the noble metals and appear in Group I in the Periodic Table. This group also includes copper to make a family of three members, although there is not much resemblance in the chemistry of any two of these elements. Copper and gold usually have a higher valence than I which is characteristic of this group.

SILVER.—Symbol: Ag; Atomic number: 47; Atomic weight: 107.88; Valence: I.

Occurrence.—Silver is found free embedded in rock, or in combination as *argentite* (Ag_2S) and as silver chloride (horn silver).

Properties.—Silver is a soft, white, lustrous metal capable of taking a high polish. It is very malleable and ductile, and the best conductor of electrical current. Air and water have no action upon it. Nitric acid attacks it readily with the formation of silver nitrate:

$$6Ag+8HNO_3 \rightarrow 6AgNO_3+4H_2O+2NO$$

Hydrochloric and dilute sulfuric acids have but slight action upon silver even at boiling temperatures, while hot concentrated sulfuric acid dissolves it forming silver sulfate and liberating sulfur dioxide. It reacts readily with the halogens. The alkalies have little or no action upon it.

Isolation.—In the combined state silver is obtained from its ores by smelting. It is removed from rock, where it occurs in the free state by crushing the rock and amalgamating the silver with mercury, after which the mercury is removed by distillation. Some of the silver salts are used in photography and medicine.

Silver nitrate, $AgNO_3$, is prepared by the action of nitric acid upon pure silver. This compound is used in the manufacture of other silver compounds and indelible inks. In medicine it is used as a caustic. In ancient times silver and gold were among the few metals known. Gold was symbolical of the sun and silver of the moon (luna), hence the term "lunar caustic" applied to this compound.

GOLD.—Symbol: Au; Atomic number: 79; Atomic weight: 197.2; Valence: I, III.

Occurrence.—Gold is ordinarily found in the free state, widely distributed but in small quantities.

Properties.—Gold is a soft, heavy, bright yellow metal, extremely malleable and ductile. It is very inactive and will not react with any of the common acids; it dissolves in nitrohydrochloric acid (aqua regia) however, and in sodium cyanide with the presence of oxygen. The fused alkalies corrode it. This metal has been basis of currency throughout the world for centuries. Large quantities are used for making jewelry, and in dentistry.

ORGANIC CHEMISTRY

Introduction.

By the middle of the seventeenth century the study of the substances occurring in Nature had so far developed that they were grouped in the three natural kingdoms of animal, vegetable, and mineral matter. At this time the study of chemistry was divided into three branches, each dealing with the substances in one of these kingdoms, and chemists devoted themselves mainly to the study of mineral or nonliving substances.

Following the discovery that certain substances are formed in the growth of both animals and plants the distinction between animal and vegetable chemistry was discarded and substances produced by organized life-processes became known as organic. It was then believed that such substances were formed as the result of the so-called "vital force" in living things and could not be artificially produced by chemists. Although Lavoisier showed that organic substances are composed largely of carbon, hydrogen, oxygen, and nitrogen, and it was known that inorganic substances could be artificially prepared in chemical laboratories, the belief that organic substances could be produced only within living organisms persisted for many years.

In 1828 Friedrich Wöhler, a German chemist, in the course of some experiments, discovered, much to his surprise, that by warming ammonium cyanate it was transformed into urea, a waste product of the body that is secreted into the urine by the kidneys. Urea is a typical organic compound and previously had been known only as a product of living organisms, while ammonium cyanate was essentially a laboratory-prepared compound. With Wöhler's production of a typical compound normally produced by the living organism from inert or nonliving matter the belief that "vital force" was necessary for the formation of organic compounds began to disappear, and by the middle of the nineteenth century had been abandoned, but the term organic chemistry survived and is used today to define this branch of chemistry, principally to distinguish it from inorganic chemistry.

Since the first synthesis of an organic compound investigations have shown that organic substances obey the same laws of composition as inorganic substances and enough syntheses of substances occurring in the living organism have been made to show that the chemical changes that take place in the living organism obey the same laws as those that occur in the laboratory. It has been further shown that carbon is present in all so-called organic compounds and organic chemistry may therefore be defined as *the chemistry of the compounds of carbon*, as they are found in Nature or have been synthesized in the laboratory. At the present time approximately 300,000 compounds of carbon are known while the compounds of all the other elements combined number only about 26,000. Organic chemistry is also defined as *the chemistry of the hydrocarbons and their derivatives.*

In the last few decades organic chemistry has made rapid progress, even to the point of producing substances which have no counterpart in Nature, as plastics, for example. Today it plays an important part in industry for the organic chemist produces antiseptics, drugs, explosives, and perfumes from coal-tar, converts cotton and wood into paper, artificial silk, explosives, photographic films, and celluloid, and prepares leather, soap, sugar, paints and varnishes, synthetic plastics and resins, rubber, and linoleum. Organic chemistry makes it possible to understand the changes that take place in the making of jam, the baking of bread, the brewing of beer, etc., and to correctly understand physiology and the chemical processes that occur in the healthy,

as well as the diseased body, a knowledge of that branch of organic chemistry known as *physiological chemistry* is necessary.

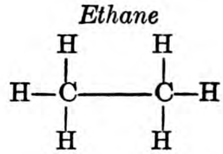
As a source of organic compounds Nature is unequalled for not only are they formed in the growth of animals and plants but they exist in and are obtained from substances that once were living animals and plants. Starch, sugar, cellulose, vegetable acids, fats, proteins, alkaloids, etc. are examples of organic compounds formed in the growth of plants and animals. By natural processes of decomposition or by laboratory methods many of these substances are broken down into simpler forms resulting in additional compounds. Many important compounds are obtained through the process of fermentation, examples being alcohol and vinegar. The destructive distillation of coal, wood, and bones produces a large number of organic compounds. From the destructive distillation of coal are obtained illuminating gas, ammonia products, coke, and coal tar. The latter is especially rich in organic compounds, there being about 200 present in it, among which are numerous phenol bodies, cresols, benzene, toluol, dye bases, etc. In the destructive distillation of wood acetone, acetic acid, methanol (wood alcohol), creosote, charcoal, and tar are some of the products. The destructive distillation of bones produces ammonia and offensively smelling substances used to denature other substances. Petroleum contains many compounds of carbon and hydrogen.

The methods used in the study, analysis, and synthesis of organic compounds are too complex for discussion here.

Two distinct divisions or types of carbon compounds, or hydrocarbons, exist: 1. The aliphatic or open-chain series; and 2. The aromatic, carbocyclic, or closed-chain series.

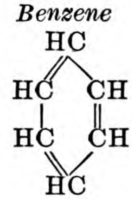
The word aliphatic is derived from a Greek word meaning fat, oil, and the aliphatic series consists of an open chain of carbon atoms, represented structurally as follows:

Ethane



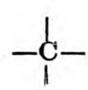
The aromatic series is characterized by a closed chain of carbon atoms known as the benzene nucleus or benzene ring, represented structurally as follows:

Benzene

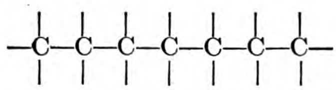


The aromatic series can be further divided into two groups, one of which, called the polymethylenes, exhibits properties closely resembling those of the aliphatic series, while the other exhibits properties differing in many respects from the aliphatic and polymethylene compounds, and is the true aromatic series.

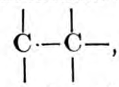
Structure and structural formulas of carbon compounds.—In the discussion of the element carbon on page 705 its valence is given as IV, shown structurally as:



and which means that it requires four monovalent atoms for saturation. It was also explained that carbon atoms possess the property of self affinity, being capable of combining with each other to form long chains. This property is shown structurally as:



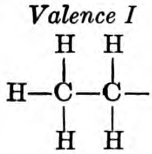
and is always true unless the saturation bonds are united with some other element. In the writing of these structural formulas it should be remembered that when two carbon atoms are shown as



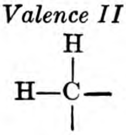
, the single bond uniting the two C's actually represents one bond from each carbon atom joined together. Also, as in the formula of benzene shown before, where no bond uniting a hydrogen atom with a carbon atom appears, it is considered that a single bond representing one bond from the hydrogen atom and one from the carbon actually exists but has been omitted for convenience in writing the formula. The formula of benzene showing all bonds appears on page 722.

When a carbon atom or group of carbon atoms is found in such a state that all bonds are not occupied, it is said to be unsaturated. Consequently compounds containing such groups are also unsaturated, and are capable of taking on additional atoms and radicals. In these groups the carbon atoms may be likened to the nucleus of an atom, and the various atoms saturating the bonds represent the electrons. The number of unsaturated bonds is equal to and identical with the group's valence:

Valence I



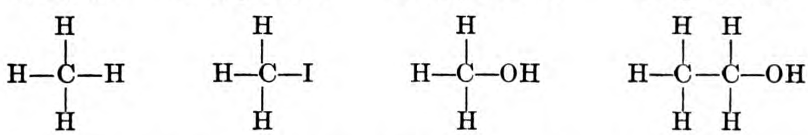
Valence II



When all the bonds of the group are satisfied, its valence being zero, a saturated compound results.

In organic chemistry the carbon atoms, as a rule, unite with hydrogen to form *hydrocarbons*. The hydrogen atoms are readily replaced by monovalent atoms or groups to form substitution or addition compounds:

Methane *Methyl iodide* *Methyl alcohol* *Ethyl alcohol*



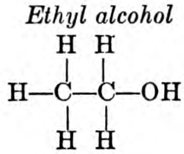
Isomerism.—When analyzing organic compounds their molecular weight and the ratio of the atoms composing them is expressed by empirical formulas, as C_2H_6O for example. As there are two substances which have the composition and molecular weight represented by this formula, it is evident that the formula must be written in two different ways if each compound is to be distinctly represented. To do this the formula for one substance, which has many of the properties of a hydroxide, is written $C_2H_5.OH$, while that for the other, which is an oxide, is written $(CH_3)_2O$. Formulas of this type are known as rational formulas. (For a general discussion of formulas *see* p. 661.)

In the study of organic substances the chemist endeavors, by means of graphic or structural formulas, to show the chemical properties possessed by a

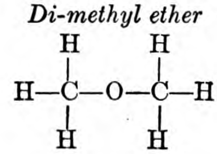
substance, in order to definitely distinguish between compounds having the same percentage composition and molecular weight. That there are many such compounds is evidenced by the fact that more than 100 compounds with the formula $C_9H_{11}NO_2$ have been described.

Such compounds are known as *isomers* and the phenomenon of the existence of such substances is termed *isomerism*. In seeking an explanation of this phenomenon chemists concluded that, if the molecules of two substances contain the same number and kind of atoms in the same relative proportions, the difference in properties exhibited by the two substances must be due to a difference in the arrangement of the atoms within the molecules. Thus, the two compounds having the formula C_2H_6O are isomers, and to distinguish between them, the chemist, in a structural formula, shows the different arrangement of the atoms within each molecule as follows:

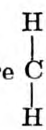
Ethyl alcohol



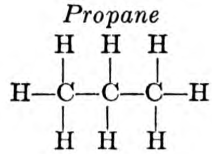
Di-methyl ether



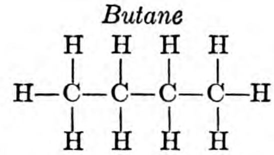
Compounds having the same percentage composition but different molecular weights are known as *polymers* and this condition of compounds is termed *polymerism*. Thus, benzene, C_6H_6, is a polymer of acetylene, C_2H_2.

Homologous series.—By observing the structural formulas of methane and ethane it will be seen that in the formula for ethane there is one more  group than in the one for methane. By the addition of similar groups other compounds are formed as:

Propane



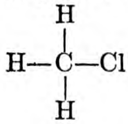
Butane



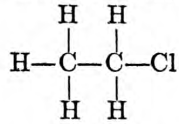
and by continuing the procedure a considerable number of hydrocarbons can be obtained. It will be noticed that each compound differs from the ones next to it by one  group, and the molecular formulas of these substances, methane, CH_4, ethane, C_2H_6, propane, C_3H_8, and butane, C_4H_{10}, show a like difference of one CH_2 group. A group of such compounds is known as a series and each compound as a member of the series. A series of compounds in which the members have similar chemical properties and each successive member differs in composition by a constant increment of CH_2 is termed a *homologous series*, the relationship is *homology*, and any member in the series is a *homologue* of any other member in it.

This principle not only applies to the hydrocarbons but to their derivatives as well:

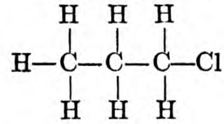
Methyl chloride



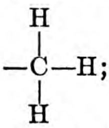
Ethyl chloride



Propyl chloride



That such a series can be built up is due to the fact that, in the methane series for example, one hydrogen atom, H, can be replaced by a CH_3 radical,



; by taking one hydrogen atom from the formula for methane, CH_4 there is left CH_3 and replacing this hydrogen atom with the radical CH_3 gives C_2H_6, the formula for ethane. (*See* p. 714.)

The fact that it is possible to classify the hydrocarbons into a small number of homologous series greatly simplifies their study. This classification is based on the chemical properties of the different hydrocarbons, which is determined largely by the relation between the carbon and hydrogen atoms in the molecules.

When brought into contact with other substances a great many hydrocarbons are very inactive, being little affected by concentrated sulfuric acid and nitric acid and resisting the action of strong alkalies and most oxidizing agents. Under certain conditions these hydrocarbons will react with chlorine and bromine and their hydrogen is replaced by the halogen. Certain hydrocarbons having these properties are classified in the series known as the *paraffins* (derived from Latin words meaning little affinity). This series is also known as the **methane series**, because methane is the simplest member of the series, and as the *marsh gas series*, because methane, a gas, is formed when dead leaves, grass, etc., disintegrate in stagnant pools of water in marshes or swamps, the gas rising in bubbles in the water when the decaying mass is stirred.

The methane series is one of the principal homologous series of hydrocarbons, and the first eight members in it are:

Name	Formula	Name	Formula
Methane	CH_4	Pentane	C_5H_{12}
Ethane	C_2H_6	Hexane	C_6H_{14}
Propane	C_3H_8	Heptane	C_7H_{16}
Butane	C_4H_{10}	Octane	C_8H_{18}

As each member of the series differs from its preceding member by a definite and constant increment of CH_2, a general formula can be used to represent that increment as: C_nH_{2n+2}, n equalling the number of carbon atoms combined. Ethane, the second member of the methane series, contains 2 combined carbon atoms, and therefore: $C_2H_{(2\times2)+2}=C_2H_6$. An easier method is to "add 12" to the subscribed numbers in the formula of the preceding member, using the 1 for the carbon atoms and the 2 for the hydrogen, thereby increasing the number of carbon atoms by 1 and the number of hydrogen atoms by 2.

The chief source of the methane series of hydrocarbons is petroleum, from which they are obtained by fractional distillation. The lower members of this series consist of gases which are dissolved in the middle or liquid members of the series. The higher members are solid forms and also are dissolved in the liquid portion. These hydrocarbons also may be obtained by dry distillation of many other organic substances, such as bituminous coal, shales, and wood.

Methane, CH_4, is the only hydrocarbon containing but one carbon atom. It is found in petroleum and also occurs as a by-product from decomposing vegetable material, especially at the bottom of marshes and pools. Methane is a colorless, odorless gas, burning with a pale, faintly luminous flame, and forming an explosive mixture with air. It may be prepared in the laboratory by heating a mixture of anhydrous sodium acetate and soda-lime. Illuminating gas, manufactured from coal, contains 30 to 40 per cent of methane.

Ethane, C_2H_6, is found in crude petroleum and natural gas. It is a colorless, odorless gas, burning with a pale flame. It may be prepared by the action of zinc or sodium upon methyl iodide:

$$\left.\begin{matrix} CH_3I+Na \\ CH_3I+Na \end{matrix}\right\}\rightarrow 2NaI+\left\{\begin{matrix} CH_3 \\ | \\ CH_3 \end{matrix}\right.$$

This building up of complex molecules from simpler ones is synthesis.

Propane, normal butane, pentane, and hexane occur as liquids in crude petroleum, the latter two especially being present in gasoline.

The hydrocarbons from $C_{16}H_{34}$ on are solid at ordinary temperatures and comprise the bulk of petrolatum products. A mixture of still higher hydrocarbons constitutes the commercial paraffin.

Hydrocarbon derivatives.

Halogen substitution products are derived from the hydrocarbons by replacing one or more of the hydrogen atoms with halogen atoms. (*See* p. 215.)

Chloroform, $CHCl_3$, (trichlormethane), is a comparatively heavy liquid with an ethereal odor and sweetish taste. It is noninflammable, very slightly soluble in water, and boils at about 61° C. Chloroform is prepared by treating acetone or ethyl alcohol with chlorinated lime. It is good solvent and a general anæsthetic.

Ethyl chloride, $\begin{matrix} CH_3 \\ | \\ CH_2Cl \end{matrix}$ is a colorless, extremely volatile, inflammable liquid having a pleasant ethereal odor and boiling between 12° and 13° C. It is prepared by treating ethyl alcohol with hydrochloric acid. In minor surgery ethyl chloride spray is used to anæsthetize local areas by freezing. It is also a general anæsthetic.

Alcohols.—An alcohol is derived from a hydrocarbon by substituting a hydroxyl group (OH) for one or more of the hydrogen atoms. Alcohols containing one OH group are monohydroxy alcohols. Those containing two OH groups are dihydroxy alcohols, etc. (*See* p. 218.)

Methyl alcohol, $\begin{matrix} OH \\ | \\ CH_3 \end{matrix}$ is a colorless liquid with a peculiar odor, burning with a nonluminous flame. It boils at 66.7° C. It is poisonous and blindness and death may result from its internal use. Methyl alcohol or "wood spirit" is obtained from the dry distillation of wood (wood alcohol) and is also prepared synthetically in large quantities under the name of methanol. It is an excellent solvent for fats, oils, and resins.

Ethyl alcohol, $\begin{array}{l}CH_3\\|\\CH_2OH\end{array}$, is a colorless, inflammable liquid with a pleasant odor, and at 95.57 per cent strength it has a boiling point of 78.3°C. It burns with a nonluminous flame and its vapors, when mixed with air, explode when ignited. Ethyl alcohol is obtained by the fermentation of grain or fruit with subsequent distillation. It is one of the best solvents and is the starting point in the manufacture of many such useful compounds as ether, chloroform, and iodoform; large quantities are used in the preparation of varnishes, perfumes, and tinctures of drugs. It is not poisonous although when taken to excess in strong beverages the effect on the system is distinctly injurious.

The general group CH_{2n+1}, is termed the "alkyl radical group". Individual radicals take their names from the corresponding hydrocarbons, as CH_3, the methyl radical, and C_2H_5, the ethyl radical.

Aldehydes.—An aldehyde is derived from a hydrocarbon by substituting an oxygen atom for two hydrogen atoms on a terminal carbon atom. (*See* p. 220.)

Formaldehyde, $\begin{array}{l}O\\\|\\CH_2\end{array}$, is a gas of extremely pungent odor, which reduces cold ammoniacal silver solution. It is prepared by passing a mixture of gaseous methyl alcohol and air over gently heated copper oxide. It is valuable as an antiseptic, fumigating agent, and preservative. Undertakers use a solution of formaldehyde of about 40 per cent in water for embalming.

Acetaldehyde, $\begin{array}{ccccc} & & H & & H\\ & & | & & |\\ H & — & C & — & C{=}O\\ & & | & & \\ & & H & & \end{array}$, is a colorless, mobile liquid, having a marked characteristic odor and boiling at 21° C. It is prepared by the oxidation of ethyl alcohol with a mixture of dilute sulfuric acid and potassium dichromate.

Ketones.—A ketone is derived from a hydrocarbon by substituting an oxygen atom on a carbon atom other than a terminal one in place of two hydrogen atoms.

Acetone, $\begin{array}{ccccccccc} & & H & & & & H & & \\ & & | & & & & | & & \\ H & — & C & — & C & — & C & — & H\\ & & | & & \| & & | & & \\ & & H & & O & & H & & \end{array}$, is a colorless liquid with a somewhat pleasant ethereal odor. It is very soluble in water and boils at 56.6° C. The chief use of acetone is as a solvent and it is prepared by the distillation of calcium acetate:

$$\left.\begin{array}{l}CH_3COO\\CH_3COO\end{array}\right\rangle Ca \rightarrow CH_3CO.CH_3 + CaCO_3$$

Ethers.—An ether is an alkyl oxide, that is, two alkyl radicals such as CH_3 or C_2H_5 are attached to an oxygen atom. (*See* p. 221.)

Ethyl ether, $\begin{array}{ccccccccccc} & & H & & H & & & & H & & H & & \\ & & | & & | & & & & | & & | & & \\ H & — & C & — & C & — & O & — & C & — & C & — & H\\ & & | & & | & & & & | & & | & & \\ & & H & & H & & & & H & & H & & \end{array}$, (commonly called sulfuric ether because sulfuric acid is used in its preparation), is a transparent, mobile liquid with a characteristic odor and a burning sweetish taste. It is somewhat soluble in water (1 — 10) and boils at about 35° C. The vapor is very in-

flammable and forms an explosive mixture with air. Ethyl ether is the most important general anæsthetic. In commerce its chief use is as a solvent.

The ethers are prepared by treating alcohols with sulfuric acid and condensing the vapors.

Organic acids.—An organic acid is derived from a hydrocarbon by substituting an oxygen atom and a hydroxyl group for the three hydrogen atoms of a methyl radical, CH_3, thus forming a carboxyl group, COOH, which is common to all organic acids. (*See* p. 225.)

Acetic acid,
$$\begin{array}{ccccccc} & & H & & O & & \\ & & | & & \| & & \\ H & — & C & — & C & — & OH \\ & & | & & & & \\ & & H & & & & \end{array}$$
is a clear, colorless liquid with a very penetrating, acid odor and sharp burning taste. It boils at 118° C. and mixes with water in all proportions. It is produced by the oxidation of alcohol in fermented liquors due to the presence of a microscopic organism, the *Mycoderma aceti.* It may also be obtained from the dry distillation of wood. Vinegar contains 4 per cent of acetic acid.

Fats or animal and vegetable oils, are esters of organic acids.

Soaps are the metallic salts of organic acids

Esters.—An ester is derived from an organic or inorganic acid by replacing the carboxyl hydrogen in organic acids, or the ionizable hydrogen in inorganic acids, with an alkyl radical. (*See* p. 226.)

Ethyl acetate,
$$\begin{array}{ccccccccccc} & & H & & O & & & & H & & H & & \\ & & | & & \| & & & & | & & | & & \\ H & — & C & — & C & — & O & — & C & — & C & — & H \\ & & | & & & & & & | & & | & & \\ & & H & & & & & & H & & H & & \end{array}$$
is a transparent, colorless liquid with a fragrant and refreshing odor and a peculiar acetous, burning taste, moderately soluble in water and easily soluble in alcohol and ether. It is inflammable and burns with a yellowish flame and acetous odor. Its most important use is as a solvent.

Ethyl nitrite,
$$\begin{array}{ccccccccc} & & H & & H & & & & \\ & & | & & | & & & & \\ H & — & C & — & C & — & O & — & N{=}O \\ & & | & & | & & & & \\ & & H & & H & & & & \end{array}$$
is a mobile liquid having a penetrating ethereal odor and peculiar stinging taste, boiling at 18° C. and burning with a bright white flame. Its alcoholic solution is Spiritus Æthylis Nitritis, U. S. P., commonly known as sweet spirit of niter. Ethyl nitrite is prepared by the action of sulfuric acid upon a mixture of sodium nitrite and alcohol.

If the alkyl radicals in a compound are designated by the letter R the various hydrocarbon derivatives may be represented by the following formulas:

Derivative	General formula	Derivative	General formula
Alcohol	ROH	Acid	RCOOH
Aldehyde	RCHO	Ester	RCOOR
Ketone	RCOR	Ether	ROR

Carbohydrates.—Among the important derivatives of the open-chain series of hydrocarbons are the saturated compounds known as carbohydrates. These compounds are produced in the growth of all green plants by the process of

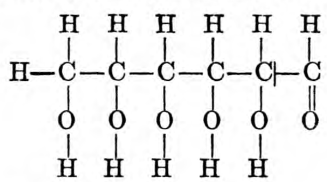
photosynthesis and constitute a major class of foods for animals. The name originated in the fact that they contain the elements carbon, hydrogen, and oxygen and their elementary composition may be expressed by the general formula CH_2O, the latter two elements being in the same proportion as they are in water. There are, however, true carbohydrates in which this ratio of hydrogen to oxygen does not exist and other compounds that are not carbohydrates in which it does exist and to such compounds the term carbohydrate is therefore not strictly applicable. Notwithstanding these facts it continues to be used as the name of this class of compounds for it is too well fixed in chemical nomenclature to be displaced. (*See* p. 241.)

Typical carbohydrates are sugars, starches, and cellulose. Their molecules are very complex and study of this class of compounds has shown that they are in general aldehyde or ketone alcohols, or compounds which are converted by hydrolysis into those types of alcohols.

The carbohydrates are also known as *saccharides* and may be divided into two classes, the *monosaccharides*, which do not hydrolyze, and the *polysaccharides*, which can be converted into monosaccharides by hydrolysis. When a monosaccharide contains the aldehyde group it is known as an aldose and when it contains the ketone group it is known as a ketose. Monosaccharides are also classified according to the number of carbon atoms in the chain as dioses, trioses, tetroses, pentoses, hexoses, etc.

The simpler carbohydrates are also called simple sugars, which are named as are the monosaccharides and are polyhydroxy derivatives of saturated aldehydes and ketones. The complex sugars, the starches, and cellulose, all of which are polysaccharides, consist of 2, 3, or many such simple sugars united into a single molecule.

The structural formula of glucose, $C_6H_{12}O_6$, a hexose sugar, is as follows:



Unsaturated hydrocarbons.

Associated with the saturated hydrocarbons in petroleum is a series of hydrocarbons each member of which contains two hydrogen atoms less than the corresponding member of the saturated series. They possess the general formula C_nH_{2n} and are known as the **olefin series.** Hydrocarbons of this series are also known as the *ethylenes,* from the first member of the series, ethylene, $\mathrm{H{-}\overset{\overset{H}{|}}{C}{=}\overset{\overset{H}{|}}{C}{-}H}$. They contain one unsaturated linkage which is indicated structurally by a double bond placed between two of the carbon atoms as shown in the formula of ethylene just given.

Their most characteristic reaction is the direct combination with two atoms of halogens to form "addition compounds". An example is the combination of two atoms of bromine to form ethylene bromide, $\mathrm{H{-}\underset{\underset{Br}{|}}{\overset{\overset{H}{|}}{C}}{-}\underset{\underset{Br}{|}}{\overset{\overset{H}{|}}{C}}{-}H}$. They have been named by adding the termination "ene" to the monad radicals derived from the corresponding saturated hydrocarbons. In their physical properties they resemble the methane homologues closely.

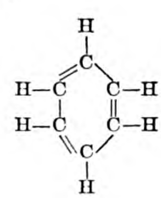
Hydrocarbons containing two hydrogen atoms less than the corresponding member of the olefin series and four less than the same member of the paraffin series are known. They may belong either to the *allenes* containing two double linkings, such as allene, $H-\overset{H}{\overset{|}{C}}=C=\overset{H}{\overset{|}{C}}-H$, or to the *acetylenes* containing one triple linking, such as acetylene, $H-C{\equiv}C-H$. The names of some of the members of these series are given in the following table:

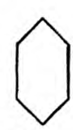
Ethylene series C_nH_{2n}		Acetylene series C_nH_{2n-2}	
Name	Formula	Name	Formula
Ethylene	C_2H_4	Acetylene	C_2H_2
Propylene	C_3H_6	Propine	C_3H_4
Butylene	C_4H_8	Butine	C_4H_6
Pentylene	C_5H_{10}	Pentine	C_5H_8
Hexylene	C_6H_{12}	Hexine	C_6H_{10}
Heptalene	C_7H_{14}	Heptine	C_7H_{12}
Octalene	C_8H_{16}	Octine	C_8H_{14}

Aromatic hydrocarbons.

The derivatives of methane and similar hydrocarbons have one common feature in that they are open-chain hydrocarbons, or aggregates of carbon atoms linked together in such a way that the end carbon atoms are distinguished from those occupying a middle position in the molecular grouping. In the *aromatic series* of hydrocarbons it is considered that the molecule contains six carbon atoms linked together in a closed chain so that no one of the six is an end carbon atom. The fundamental hydrocarbon of this series is benzene, the structural formula of which is shown on page 714.

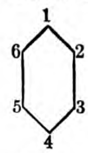
Before continuing with the discussion of the aromatic hydrocarbons a brief explanation of the benzene ring is essential. If the structural formula of benzene is so written as to show all bonds linking the carbon and hydrogen atoms together it will appear as:



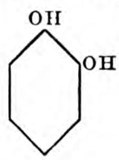
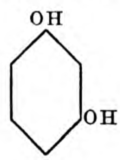
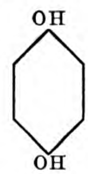
This is a cumbersome method and for convenience a simple oblong hexagon  is ordinarily used. At each angle of the hexagon it is assumed a CH group is situated and the hexagon so written is always understood to mean C_6H_6.

The hydrogen atoms in benzene are replaceable by the substitution of other elements or groups, and when only a single hydrogen atom is replaced, as in the formation of phenol from benzene, the replacing OH group may be shown at any angle of the hexagon but usually is placed at the top, as  which

it is understood to be C_6H_5OH, or phenol. (*See* p. 222.) If, however, two hydrogen atoms are replaced it is necessary to know at which angles to place the replacing element or group. To facilitate this the angles of the hexagon are given imaginary numbers starting with **1** at the top and proceeding clockwise, thus:

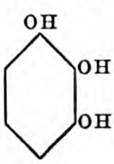
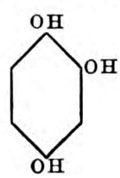
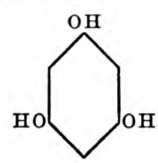


Replacement or substitution of two hydrogen atoms can take place in three different ways, to form three isomeric compounds, as shown in the following structural formulas where the OH group is again used as the substituent:

Each of the compounds shown, in which 2 hydroxyl groups are substituted for 2 hydrogen atoms, is dihydroxybenzene, but to designate the structure the figures of the substitution places or the prefixes *ortho*, *meta*, or *para* are added. Thus the first compound shown is known either as 1–2 or ortho, the second as 1–3 or meta, and the third as 1–4 or paradihydroxybenzene.

Substitution of three hydrogen atoms in the benzene ring also gives three isomeric compounds as follows, with OH as the substituent:

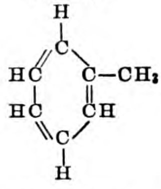




The substituent groups in the compounds shown are said to be *vicinal* (adjoining or consecutive), in the one at the left, *asymmetrical* in the one in the center, and *symmetrical* in the one at the right. These isomeric compounds, all of which are trihydroxybenzene, are designated by numbers or by the first letters of the words indicating the positions, as 1–2–3 or v-, 1–2–4 or a-, and 1–3–5 or s-trihydroxybenzene.

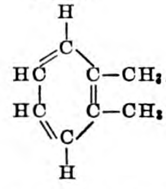
For further information concerning the benzene ring reference should be had to any standard text book on Organic Chemistry.

Resuming discussion of the aromatic series, homologues of this series are formed by the replacement of one or more of the hydrogen atoms by methyl and ethyl groups:

Toluene



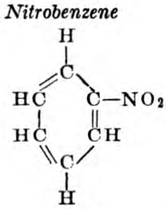
Xylene



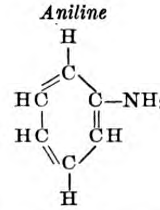
The limit of this replacement is reached when other atoms or groups have been substituted for the six hydrogen atoms. Both the hydrocarbons of this series and the substitution derivatives are quite stable.

The benzene derivatives are not convertible into methane derivatives by the addition of halogens or other atomic groups; benzene, C_6H_6, cannot be converted into hexane, C_6H_{14}, by any means, direct or indirect. In fact, it is strikingly evident that C_6H_6 is a peculiarly constituted molecule, which resists change and remains substantially intact through all the substitutions that may be effected. It cannot be transformed into a simple molecule containing 5, 4, or 3 carbon atoms; when oxidized, it reverts into carbon dioxide and water. More than half of all the carbon compounds are benzene derivatives. Among the important derivatives is nitrobenzene which is prepared by treating benzene with nitric acid.

Nitrobenzene



Aniline



Nitrobenzene is reduced by nascent hydrogen to aniline, from which the "aniline dyes" are derived. The general formula for the benzene series is represented as C_nH_{2n-6}.

The scope of Organic Chemistry is practically unlimited and in this chapter it has not been possible to give more than a very brief outline of this most interesting subject. As has been previously stated many hundred times more compounds than Inorganic Chemistry contains are already known, and what future research in this realm may produce is purely a matter of speculation.

ANALYTICAL PROCEDURES

The division of chemistry which deals with the composition of substances is called Analytical Chemistry and its procedures are known as chemical analyses. It is divided into two parts: 1. *Qualitative analysis,* in which the constituents in a given compound are identified; and 2. *Quantitative analysis,* in which the percentage of various elements or compounds is determined.

The methods used to make these determinations are based upon the simple laws of chemistry and the similarity of properties and reactions existing among certain groups of elements and their compounds.

Because the molecules of a substance necessarily must have intimate contact to facilitate a complete reaction, the substance to be analyzed is first dissolved in a liquid, usually water. This induces the substance to dissociate into its various ions. The determinations in chemical analysis are based upon the conduct of these ions and their reactions with various reagents, and therefore a knowledge of the theories and laws of ionization as related to the various elements and reagents employed is necessary. A brief discussion of ionization as regards its use in chemical analysis will follow.

The first step in proceeding with a chemical analysis is either to isolate the various components to be determined by precipitation of their ions and subsequent filtration, or to treat their solution in such a manner that their reaction with the indicated reagents is not modified or obscured.

Pure water freezes at 0°C., but when a substance is dissolved in water the freezing temperature ordinarily is depressed in proportion to the amount added. It is evident, therefore, that the depression of the freezing point of water is proportional to the number of molecules of the substance dissolved in a given

quantity of water. For example, if a mole (*see* page 663) of alcohol (46 Gms.) is dissolved in sufficient water to make 1,000 cc, the freezing point is lowered 1.86° C. Similarly, one mole of many other substances, such as sugar or glycerin, when dissolved in sufficient water to make 1,000 cc, depresses the freezing point of the water 1.86° C.

Acids, bases, and salts, in the same equivalent proportion, cause the freezing point of water to be depressed even more than 1.86° C., in many cases as much as 2, 3, or 4 times. In dissolving one mole of NaCl in sufficient water to make 1,000 cc of water, the freezing point is lowered nearly 2 times 1.86° C. From this fact it might seem that there are twice as many particles present in the solution from a mole of NaCl as there are from a mole of alcohol, but as a mole of one substance contains the same number of molecules as that of any other substance, there therefore cannot be twice as many molecules of NaCl as there are of alcohol. Consequently, it becomes evident that the molecules of NaCl split into two particles.

One molecule of $BaCl_2$ dissolved in sufficient water to make 1,000 cc depresses the freezing point of the water nearly 3 times 1.86° C., and hence it is obvious that its molecules have split into 3 distinct particles.

Further evidence of this splitting process is the precipitation of AgCl when $AgNO_3$ is added to a solution of NaCl or $BaCl_2$. This precipitation will occur with any chloride regardless of what active metal is combined with the Cl. Therefore, it is apparent that the characteristics of a solution are to some extent due to the functions of the constituent parts of the salts, rather than the molecules of the salts as a whole.

In like manner all acids exhibit the same properties which classify them as acids (turn litmus red, have a sour taste, decompose carbonates) regardless of what elements or groups of elements are combined with the hydrogen which is common to all acids. This shows that the properties of an acid are dependent upon its hydrogen, for that is the only element common to all acids; the other elements combined with hydrogen in acids have extremely different properties. The characteristic properties of all the bases in solution are derived from the hydroxyl radical, (OH), which is the only unit common to all bases.

These facts demonstrate that acids, bases and salts, when dissolved in water, split up into their constituents in the following manner:

$$HCl \leftrightarrows H^+ + Cl^-$$
$$NaOH \leftrightarrows Na^+ + OH^-$$
$$HaCl \leftrightarrows Na^+ + Cl^-$$
$$H_2SO_4 \leftrightarrows H^+ + H^+ + SO_4^{--}$$
$$BaCl_2 \leftrightarrows Ba^{++} + Cl^- + Cl^-$$

The hydrogen formed when an acid splits up in solution behaves quite differently from that found in the gaseous state or in compounds such as the hydrocarbons. Likewise, the sodium formed is quite different from metallic sodium which reacts violently with water. This is because these particles, called cations or anions according to their nature, carry electric charges, and when they come in contact with the cathode or anode electrode, as the case may be during the process of electrolysis, they give up their electrical charge and assume their natural state. (*See* previous discussion of electrolysis.) Substances which permit the passage of an electrical current through their solutions, and which, from the consideration of their depression of the freezing point, do split into their constituent parts, are known as electrolytes. Substances which do not permit the passage of electrical current through their solutions and give normal

freezing point depressions (1.86° C. per one mole in sufficient water to make 1,000 cc) are known as non-electrolytes. From these observations the theory of electrolytic dissociation, or ionization, has been developed, in which it is considered that:

1. When an acid, base, or salt is dissolved in water it instantly separates or dissociates into particles called ions;

2. These ions are electrically charged, hydrogen and the metals carrying positive charges and the non-metallic elements and radical groups except NH_4, carrying negative charges. The total of the positive and negative charges is equal, that is, they balance each other; and

3. When oppositely charged ions in a solution collide they reform, for an instant, molecules of the original substance. The process of ionization is therefore reversible, and is indicated by double arrows $\rightleftarrows$. The solution will contain, at a given instant, a definite number of whole molecules along with the ions. Ionization is not complete until the solution is so greatly diluted that collision of the ions rarely occurs. The number representing the percentage of molecules ionized at a given instant is called the *degree of ionization.* Thus, if at a given instant, 90 out of every 100 molecules of a substance are ionized and 10 still exist as whole molecules, the degree of ionization is 0.90 or 90 per cent.

Acids, such as HCl, HNO_3 and H_2SO_4, which have a high degree of ionization (0.50 to 0.90) in normal solutions are called strong acids. Other acids, such as $H.C_2H_3O_2$, H_2S and H_2CO_3, which are ionized very slightly (less than 0.1) in normal solution are known as weak acids. There is, however, no very distinct demarcation between weak and strong acids, all acids being completely ionized in very dilute solutions.

Bases, such as NaOH and KOH, which have a high degree of ionization in normal solutions are called strong bases. Those having a low degree of ionization, such as NH_4OH, are called weak bases.

Nearly all the soluble salts are highly ionized, even those derived from weak acids.

When ions are removed from a solution by the addition of another substance, the relative velocity at which the molecules break up to form new ions will be increased, although the number of ions present at a given instant will remain the same. For example, HCl is normally ionized 80 per cent, in a normal solution, into positive hydrogen (H^+) and negative chlorine (Cl^-) ions. If a mole of NaOH is added to the solution, the H^+ ions unite with the OH^- ions derived from the NaOH to form H_2O which is very slightly ionized. Therefore, the H^+ ions are removed from the solution. HCl is constantly ionizing, but the OH^- ions continuously remove the H^+ ions from the solution, preventing the reforming of HCl molecules. As a result, the HCl molecules are progressively broken down until no more molecules of HCl remain. In the same way the ions of NaOH undergo a like process. When there are no longer molecules of HCl or of NaOH left to ionize, the solution exhibits neither the properties of an acid nor a base; hence it is termed neutral. The reactions which take place are indicated by the following equation:

$$\begin{array}{rcccc} HCl \leftrightarrows & H^+ & + & Cl^- \\ & + & & + \\ NaOH \leftrightarrows & OH^- & + & Na^+ \\ & \downarrow\uparrow & & \downarrow\uparrow \\ & H_2O & & NaCl \end{array}$$

Standard solutions are those which contain a known and definite amount of a given substance. They are divided into two classes, *molar* and *normal.*

Molar solutions.—The concentration, or quantity of solute a solution contains, is often an important factor in chemical reactions. The ratio of solute to a definite volume of solvent is usually expressed in grams per 1000 cc, ounces per quart, or pounds per gallon. These are convenient arbitrary units selected by man. On the other hand there are certain units which are constant in Nature and must be considered in chemical reactions, for, in truth, chemistry is a duplication, by man, of natural processes.

The natural unit of an element is the atom and is the unit which is exchanged in chemical reactions. In the case of compounds the natural unit is the molecule. Therefore, the natural unit of weight in a chemical reaction is the actual weight of each individual atom concerned.

It is readily apparent that the actual weights of the atoms and molecules are too small for convenient use. The actual weight of a hydrogen atom has been determined as 0.000,000,000,000,000,000,000,001,662 Gm., and that of oxygen as 0.000,000,000,000,000,000,000,026,4 Gm., the latter being nearly 16 times the former. Due to the impracticability of working with such voluminous figures, relative weights rather than absolute weights are used. The relative weights are the same regardless of the number of atoms compared. Thus, one atom of oxygen is nearly 16 times as heavy as one hydrogen atom; 2 oxygen atoms are nearly 16 times as heavy as 2 hydrogen atoms, etc.

One gram of hydrogen contains a definite number of hydrogen atoms. To acquire the same number of oxygen atoms it would be necessary to have nearly 16 Gm. of oxygen. Therefore, the relative atomic weight of an element in grams contains the same number of atoms regardless of what element is considered. The calculation of the relative atomic weights is based on oxygen (O=16) as the arbitrary standard; then 16 Gm. of oxygen contain the same number of molecules as 1.0078 Gm. of H; 22.99 Gm. of Na; 32.06 Gm. of S; 35.457 Gm. of Cl; etc.

One molecular weight in grams is called a *mole*. A solution containing one mole of solute in 1,000 cc of the solution (not the solvent) is termed a *molar solution*. Such molar solutions are designated by the abbreviations M/1 or $\frac{M}{1}$ and solutions containing one-half mole, one-tenth mole, etc., in 1,000 cc, as M/2 or $\frac{M}{2}$, M/10 or $\frac{M}{10}$, etc. One mole of any substance contains the same number of molecules as a mole of any other substance. Hence, a mole of a given substance has the exact number of molecules necessary to react completely with one mole of another substance, or with a definite multiple or fraction thereof. Thus:

$$\begin{array}{rcccccc}
H_2SO_4 \rightleftarrows & H^+ & + & H^+ & + & SO_4^{--} & \\
 & + & & + & & + & \\
2NaOH \rightleftarrows & OH^- & + & OH^- & + & Na^+ & + Na^+ \\
 & & \upharpoonleft\!\downharpoonright & & & \upharpoonleft\!\downharpoonright & \\
 & & 2H_2O & & & Na_2SO_4 &
\end{array}$$

In this reaction one molecule of H_2SO_4 combines with two molecules of NaOH to form a salt and a neutral solution; or one mole of H_2SO_4 reacts with two moles of NaOH. With a molar solution of NaOH and a molar solution of HCl, it will take the entire liter of NaOH solution to neutralize the liter of HCl solution, or 1 cc of NaOH solution to neutralize 1 cc of HCl solution. Molar solutions are convenient because 1 cc of a molar solution of one substance will neutralize 1 cc or 2 cc or 3 cc or ½ cc or ⅓ cc or ¼ cc of a molar solution of some other substance. The reaction between NaOH and H_2SO_4 demonstrates why the numbers are not always 1:1.

It is obvious that it would be more convenient to have all standard solutions neutralize each other cc for cc rather than in multiples of 2, 3, 4, etc. This can be accomplished by the use of normal solutions.

Normal solutions.—Solutions which contain 1.0078 Gm. of replaceable hydrogen or its equivalent weight of solute in 1,000 cc of solution are termed *normal solutions.*

It has been noted that all acids derive their characteristics from the ionizable hydrogen which they contain, this hydrogen being readily replaceable by active metals. In preparing a normal solution of an acid, it is necessary to consider the number of hydrogen atoms contained in the molecule. As the molecular weight is derived from the sum of the atomic weights, it is convenient in preparing standard solutions to use the molecular weight in grams. To prepare a normal solution of HCl first note that the molecular formula shows 1 replaceable atom of hydrogen and that the molecular weight is 36.465 Gm. in which 1.008 Gm. is the weight of 1 atom of replaceable hydrogen; therefore, 36.465 Gm. of HCl is to be dissolved in sufficient water to make 1,000 cc. In preparing normal solutions of acids containing more than 1.008 Gm. of replaceable hydrogen, it is necessary to use that portion of the molecular weight in grams which will represent 1.008 Gm. of replaceable hydrogen. For example: H_2SO_4 contains 2 replaceable hydrogen atoms and its molecular weight is 98.07; therefore, $\frac{98.07}{2} \rightarrow 49.03$ Gm. of H_2SO_4, or the equivalent of 1.008 Gm. of H^+, must be used. H_3PO_4 contains 3 replaceable hydrogen atoms and its molecular weight is 98.04 Gm.; therefore, $\frac{98.04}{3} \rightarrow 32.68$ Gm. of H_3PO_4, or the equivalent of 1.008 Gm. of H^+, must be used.

For convenience in designating a normal solution the abbreviation N/1 or $\frac{N}{1}$ is used. In normal solutions or fractions of normal, appropriate numbers are placed below or after a line next to the letter N. Thus, a half normal solution is designated as N/2 or $\frac{N}{2}$, a fifth normal solution as N/5 or $\frac{N}{5}$, a tenth normal solution as N/10 or $\frac{N}{10}$, etc. Solutions which are stronger and therefore are multiples of normal solutions are represented by numbers placed before the letter N. Thus, a double normal solution is designated as 2N, a solution 5 times normal as 5N, etc. In preparing solutions which are fractions of normal, the designated fraction of the molecular weight (or of its proportionate part representing 1.008 Gm. of H^+ in 1,000 cc) is used, as, for a N/10 solution of HCl, 1/10th of 36.47 Gm. or 3.647 Gm. (the figure in the third decimal place of the molecular weight being dropped and that in the second increased by 1). For solutions which are multiples of normal, the designated multiple is used, as, for a 5/N solution of HCl, 5×46.465 Gm., or 182.325 Gm.

Bases do not contain H^+ ions but ionize into $R^+ + OH^-$ (R being any element forming part of a base), each OH^- ion being capable of combination with one H^+ ion. In preparing a normal solution of a base the molecular weight (or its fractional part containing OH^-, which is the equivalent of one H^+) is used. The molecular weight of NaOH, 40.00 Gm., is used in 1,000 cc to prepare the normal (N/1) solution of NaOH.

In order to make the H^+ equivalent more comprehensive and concise the following formula may be used:

$$H^+ \text{ equivalent weight } \frac{\text{molecular weight}}{\text{total positive valence}}$$

Then, to prepare a normal solution of an acid containing 1, 2, or 3 replaceable hydrogens the equations would be:

$$HCl: \frac{36.465}{1} = 36.465 \text{ Gm. in } 1{,}000 \text{ cc.}$$

$$H_2SO_4: \frac{98.07}{2} = 49.03 \text{ Gm. in } 1{,}000 \text{ cc.}$$

$$H_3PO_4: \frac{98.04}{3} = 32.68 \text{ Gm. in } 1{,}000 \text{ cc.}$$

The amount of soluble salts to use in preparing normal solutions may be determined in the same manner, as:

$$Ba^{++}Cl_2^{--}: \frac{208.27}{2} = 104.13 \text{ Gm. in } 1{,}000 \text{ cc.}$$

Hydrogen ion concentration and Indicators.

It is often desirable to determine the acidity or alkalinity of a solution, or the point of neutrality when the positive hydrogen (H^+) ions and the negative hydroxyl (OH^-) ions are equal. By the use of litmus paper the relative difference between acidity, alkalinity, and neutrality may be demonstrated, but often this procedure is unsatisfactory, in that it does not denote the degree in which these properties are present.

Solutions containing a preponderance of H^+ ions, as previously stated, are considered acid and solutions containing a preponderance of OH^- ions are alkaline, the degree of acidity or alkalinity being dependent upon the number of these ions present. In order to define a definite degree of ionization, either of H^+ or OH^-, a convenient scale is necessary. In order to have a comparable scale there must be a constant, so, in order to determine the degree of ionization, a scale has been devised using distilled water as a constant, because distilled water has a relatively unappreciable dissociation into H^+ and OH^- ions.

By electrical-conductivity measurements the *degree of ionization* of distilled water has been determined as 0.000,000,1, or, to use a negative exponent, 10^{-7}. This means that in 1,000 cc of distilled water there is present only 0.000,000,1 gram of hydrogen ion (H^+), the balance of the hydrogen being in the molecular form as H_2O. Likewise the *ionization constant* of distilled water has been determined to be 0.000,000,000,000,01 or, to use a negative exponent, 10^{-14}. This ionization constant is the product of the multiplication of the hydrogen (H^+) concentration and the hydroxyl ion (OH^-) concentration as shown by the following dissociation or ionization equation for distilled water:

$$\underset{(10^{-7})}{H^+} \times \underset{(10^{-7})}{OH^-} = \underset{(10^{-14})}{\text{Constant}}$$

Using this factor as a constant, a scale of measure is formulated in terms of potential hydrogen, pH, (ionized hydrogen) to cover the complete range of acidity and alkalinity. The equivalent pH value for any given H^+ is the logarithm of that concentrate's reciprocal. For example: 10,000,000 is the reciprocal of 0.000,000,1 and the log of this is 7 which is the pH value for the H^+ concentration of 0.000,000,1.

In order to eliminate the unwieldy ciphers the H^+ concentrations are expressed by negative exponents. The mathematical calculations by which the pH values are obtained are too complicated, especially in determining the fractional parts, to be discussed in this chapter. Inasmuch as H^+ concentrations are universally expressed in pH values, which are readily determined, a knowledge of logarithms is not necessary to determine the degree of acidity or alkalinity. However, it is to be remembered that the pH values are represented by logarithms, hence, the numerical order in the pH scale is inversely proportional to the H^+ concentration it represents. With an increase in pH

values from 0 to14 there is a decrease in H^+ concentration with a corresponding increase in OH^- concentration to maintain the equilibrium of 10^{-14}, the ionization constant of H_2O. At *p*H 7.0 there is an equal number of H^+ and OH^- ions, the concentration in each group being 10^{-7} hence, *p*H 7.0 is the neutral point. A decrease in *p*H from 7 to 0 is accompanied by a progressive increase in H^+ ions, and in acidity, with a decrease in OH^- ions. An increase in *p*H from 7 to 14 is accompanied by a progressive decrease in H^+ ions with an increase in OH^- ions, and in alkalinity. Because logarithms are used, in the *p*H scale it is to be noted that *p*H 6 represents 10 times as many H^+ ions as *p*H 7, and that *p*H 5 represents 100 times as many H^+ ions as *p*H 7, etc.

*p*H Scale

Hydrogen ion concentration	*p*H value	Hydroxyl ion concentration
1.0 or 10^{-0}	*p*H 0.0	10^{-14} or 0.00000000000001
0.1 or 10^{-1}	*p*H 1.0	10^{-13} or 0.0000000000001
0.01 or 10^{-2}	*p*H 2.0	10^{-12} or 0.000000000001
0.001 or 10^{-3}	*p*H 3.0	10^{-11} or 0.00000000001
0.0001 or 10^{-4}	*p*H 4.0	10^{-10} or 0.0000000001
0.00001 or 10^{-5}	*p*H 5.0	10^{-9} or 0.000000001
0.000001 or 10^{-6}	*p*H 6.0	10^{-8} or 0.00000001
0.0000001 or 10^{-7}	*p*H 7.0	10^{-7} or 0.0000001
0.00000001 or 10^{-8}	*p*H 8.0	10^{-6} or 0.000001
0.000000001 or 10^{-9}	*p*H 9.0	10^{-5} or 0.00001
0.0000000001 or 10^{-10}	*p*H 10.0	10^{-4} or 0.0001
0.00000000001 or 10^{-11}	*p*H 11.0	10^{-3} or 0.001
0.000000000001 or 10^{-12}	*p*H 12.0	10^{-2} or 0.01
0.0000000000001 or 10^{-13}	*p*H 13.0	10^{-1} or 0.1
0.00000000000001 or 10^{-14}	*p*H 14.0	10^{-0} or 1.0

Hydrogen ion determinations are made either electrochemically or colorimetrically. Electrical-conductivity tests for the quantitative determination of H^+ ions require elaborate apparatus and special training, whereas colorimetric determinations may be made comparatively accurately and conveniently with inexpensive apparatus, *buffer solutions*, and *indicators*.

A **buffer solution** is one that has a definite concentration of hydrogen ions (H^+) which is not altered by dilution, and is prepared by dissolving definite weights of the salts of weak acids and of weak bases or of both in sufficient water to make 1000 cc. As a rule, two buffer solutions are used in conjunction, one containing a preponderance of H^+ ions and the other a preponderance of OH^- ions. By mixing prescribed volumes of these solutions together it is possible to produce a solution of any desired *p*H value. Due to the low ionization value of the substances used, the $H^+ + OH^-$ equilibrium is maintained under ordinary circumstances and the *p*H value of their combination remains constant. For detailed preparation of buffer solutions refer to "Clinical Diagnosis by Laboratory Methods", Todd and Sanford, p. 668.

Indicators are natural or synthetic organic substances used in chemistry to show by a color change whether a substance is acid or alkaline in reaction. A familiar example is blue litmus which turns red with acids and is unchanged with alkalies.

To determine the *p*H value of a given solution, a range of known *p*H values is prepared with buffer solutions contained in a series of test tubes, to which is added an indicator that will cover the *p*H range desired. An equal amount of indicator being added to each tube, a distinct and progressive range of colors develops. An equivalent amount of indicator is added to a proportionate part of the unknown solution and the resulting color compared with the known

range, the pH value of the unknown solution being identical with that of the tube whose color it matches.

Following are some of the more common indicators used and the pH range they cover:

Indicator	pH range	Color change	
		Acid	Alkaline
Brom-phenol blue	3.0– 4.6	Yellow	Blue.
Methyl red	4.4– 6.0	Red	Yellow.
Brom-cresol purple	5.2– 6.8	Yellow	Purple.
Brom-thymol blue	6.0– 7.6	Yellow	Blue.
Phenol red	6.8– 8.4	Yellow	Red.
Cresol red	7.2– 8.8	Yellow	Red.
Phenolphthalein	8.3–10.0	Colorless	Red.

Phenolphthalein is one of the most common indicators used, especially in titrating acids and alkali hydroxides. However, care must be employed in the choice of an indicator, as some are affected in the chemical reactions used for analysis, e. g., when titrating carbonates and ammonium compounds phenolphthalein cannot be used. In titrating carbonates methyl orange is used. In ammonia titration cochineal is used. It is also important to note if the indicator to be used covers the pH range in which the end-point is to be obtained.

Qualitative anaylsis

Qualitative analysis is concerned only with the identification of the constituents of a compound. As previously stated the elements are divided into the metals and nonmetals. Upon solution, a substance dissociates into ions, the metals forming the positive ions and the nonmetals the negative ions. In determining the character of the positive ions it is found that a number of elements, often elements in the same family, are similar in that one type of their salts is insoluble in water which makes it possible to classify them in groups by precipitation and filtration. After the element has been isolated it is usually identified by its reaction with known reagents or by the color of its precipitate. The negative ions are also identified in a similar manner.

Quantitative analysis.

Quantitative analysis is concerned with the determination of the percentage of various elements and compounds contained in a substance. Quantitative analysis may be of two types: 1. *Ultimate analysis* in which the various elements present in a substance are determined, as the determination of sodium, sulfur and oxygen in sodium sulfate; and 2. *Proximate analysis* in which is determined the groups of elements which act in a similar manner when treated with a reagent or series of reagents, as in determining the amount of insoluble matter in limestone.

Quantitative methods of analysis may be performed by **gravimetric or volumetric** procedures. In gravimetric methods the substance to be determined is isolated, dried, and weighed. In visual volumetric analysis the substance to be determined is titrated against a volumetric solution containing a known quantity of material that will produce a definite reaction with the unknown. The completion of the reaction is signified by an appearance, the disappearance, or a change of color either natural or from an indicator that has been added, or by the end or beginning of precipitation.

154294°—39——47

Visual volumetric analysis is performed by one of the following methods:

Acidimetry, in which the percentage of an acid is determined by neutralization with a standard alkali solution. An indicator is used.

Alkalimetry, in which the percentage of an alkali is determined by neutralization with a standard acid solution. An indicator is used.

Iodimetry, in which the percentage of a substance is determined by indirect oxidation through the use of iodine. Iodine is also used in connection with the estimation of other halogens.

Oxidimetry, in which the percentage of a substance is determined by direct oxidation through the use of potassium permanganate or some other substance capable of yielding oxygen.

In volumetric determinations there are three general types of reactions employed, *direct, indirect* and *residual.*

In the **direct type** a known solution is added directly to the unknown until the reaction is complete, as in alkalimetry and acidimetry.

The indirect type is used where the quantity of the unknown cannot be conveniently determined unless it is acted upon by a second substance to form another compound which is in proportion to the quantity of the unknown. This second compound is then titrated to find the percentage of the unknown, as in the determination of chlorine. The substance containing chlorine is acted upon by potassium iodide, iodine being liberated in proportion to the amount of chlorine; the iodine is then titrated against a known solution of sodium thiosulfate, starch paste being used as the indicator.

The residual type is used where it is impossible or extremely difficult to obtain a reaction between the unknown and the reagents when equivalent quantities are added to each other. Therefore, an excess of the standard solution is added to the unknown to obtain a complete reaction and then a second standard solution is used to titrate the amount of the first solution that remains. The percentage of the unknown is determined from the quantity of the first solution used in the reaction, as in the determination of sodium chloride. A definite quantity of silver nitrate is added in excess to the unknown solution. After the reaction is complete the amount of silver nitrate left from the reaction is titrated against a standard solution of sodium sulfocyanate, ferric ammonium alum being used as an indicator. The amount of silver reacting with the sulfocyanate solution is then subtracted from the original quantity added. From this the equivalent amount of sodium chloride is determined. This is known as "back titration".

If it is desired to determine the percentage of sodium hydroxide in a given solution proceed in the following manner:

1. Measure the solution to obtain its volume.

2. Into a 25 cc burette place an N/1 solution of hydrochloric acid and bring the meniscus exactly to the 0 mark.

3. Place 10 cc of the sodium hydroxide solution in a 250 cc white porcelain evaporating dish and add 3 drops of phenolphthalein indicator.

4. Allow the HCl solution to run slowly into the evaporating dish containing the NaOH solution, stirring constantly.

5. When the solution becomes visibly paler, add the HCl, a drop at a time, noting the reading on the burette after each addition. When the NaOH solution shows just the faintest tint of pink and the addition of one more drop will make it colorless, the end-point of the reaction has been reached. From the reading on the burette calculate the percentage of NaOH.

If the NaOH solution measured 350 cc and neutralization was obtained with 8 cc of HCl, the percentage is calculated in the following manner:

N/1 solution of NaOH contains 40.0 Gm. of NaOH per 1000 cc.

1 cc of N/1 HCl is the equivalent of 0.040 grams of NaOH. Therefore: $8 \times 0.040 = 0.320$ Gm. of NaOH in 10 cc, and in 350 cc there are: $\frac{350}{10} \times 0.320 =$ 11.21 Gm. of NaOH.

The percentage of an acid is determined in the same manner.

Other analytical procedures involve more complicated reactions and for these reference should be made to a standard text on chemical analysis.

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CHAPTER X

ANÆSTHESIA

Anæsthesia is the state in which total or partial loss or absence of feeling or sensation exists and may be the result of disease or injury, or of the administration of an anæsthetic agent. It is known as *general* or *regional* (*local*), according to the extent of insensibility to pain.

The combination of gas-ether anæsthesia is still used extensively, although it is being replaced to a great extent by the cyclopropane-ether-oxygen mixture. Ethylene-oxygen is being used less because it has only a 25 per cent potency, while cyclopropane, with 100 per cent potency, gives the same rapid type of induction and recovery, with deeper anæsthesia. As more surgeons become familiar with spinal anæsthesia, recognizing its safety, they adopt it for most operations below the diaphragm. Patients have less postoperative complications from spinal and regional anæsthesia than from the other types.

REGIONAL ANÆSTHESIA

Regional or local anæsthesia produces loss of sensibility to pain in the area or region involved, which may be small or extensive, depending upon the method used and site of injection. There is no loss of consciousness. There are four different types of regional anæsthesia: 1. Surface or topical anæsthesia; 2. Infiltration anæsthesia; 3. Block anæsthesia; and 4. Spinal anæsthesia.

Surface or topical anæsthesia.

This type of regional anæsthesia is produced by the instillation or application of an anæsthetic agent directly on the tissue to be anæsthetized, usually the mucous membranes of the eye, nose, mouth, urethra, and anus. It is also applicable to painful skin ulcers and itching dermatitis. The four most commonly used drugs are: Cocaine hydrochloride, ($C_{17}H_{21}NO.HCl$); metycaine hydrochloride, ($C_6H_4.COO(CH_2)_3.NC_6H_{12}.HCl$); nupercaine hydrochloride, ($C_9H_5N.OC_4H_9(2).CONH(CH_2)_2N(C_2H_5)_2HCl(4)$; and pontocaine hydrochloride, ($C_4H_9NH.C_6H_4COO.C_2H_4N(CH_3)_2.HCl$).

COCAINE HYDROCHLORIDE.—For instillation in the eye a 4 per cent solution is used. Two to four drops instilled in the eye at intervals of 3 to 5 minutes for a period of one-half hour will produce sufficient anæsthesia to permit operations on the eye. For internasal operations the nose is packed with pledgets of cotton soaked with a 20 per cent solution.

Cocaine should never be used for local infiltration, block or spinal anæthesia as it is a very potent protoplasmic poison. Certain individuals are very susceptible to its action and grave systemic reaction may result even with topical applications. This reaction is manifested by rapid pulse, dilatation of the pupils, facial pallor, shortness of breath, anxiety and restlessness. The more serious cases may have convulsions and loss of consciousness, with the skin becoming cold and livid. Treatment for restlessness and anxiety consists in giving a barbiturate, such as pentobarbital sodium, 3 grains intravenously, and in addition institute artificial respiration. Do not give epinephrine, as the cocaine has already caused vasoconstriction.

METYCAINE HYDROCHLORIDE.—This drug can be used for topical application, local infiltration or spinal anæsthesia. It is somewhat more toxic than procaine, but its potency permits the use of a smaller dose, especially for spinal anæsthesia, thus making the therapeutic doses of each equal as to toxicity. For surface or topical anæsthesia a 1 per cent solution is used, and for infiltration anæsthesia 0.5 to 2 per cent.

NUPERCAINE HYDROCHLORIDE.—In a 1 per cent solution it will anæsthetize mucous membranes, but due to its extreme potency and toxicity it should not be used repeatedly over a period of several days.

PONTOCAINE HYDROCHLORIDE.—This drug is 10 times more toxic and 10 times more potent than procaine of which it is a derivative. For mucous membrane anæsthesia it can be used in a 1 per cent solution. It may also be used in a 1 per cent ointment, but like nupercaine, should not be used over a long period of time. Its most common use is for spinal anæsthesia.

Infiltration and Block anæsthesia.

Local infiltration consists of injecting the tissues at the site of the incision. All tissues to be cut must be injected. This method is applicable for minor surgical procedures but should not be used where tissues with infection are to be incised, as the injection will be painful and there is chance of spreading the infection to the lymphatics or blood stream.

Block anæsthesia is produced by injecting the solution around the area to be operated on. This procedure is considered superior to local infiltration and is applicable to nearly every part of the body. After local infiltration the incision can be made immediately, but with field block 5 to 15 minutes must intervene.

In nerve block the injection is made around or into the nerves which supply the field of operation.

Procaine hydrochloride ($C_{13}H_{20}O_2N_2.HCl$), different brands of which are known as Novocaine and Neocaine, is the anæsthetic of choice for infiltration and block anæsthesia. A 0.5 per cent solution is sufficiently strong for all infiltration and field block anæsthesia. For nerve block a 1 or 2 per cent solution should be used. The anæsthesia may be prolonged by the addition of epinephrine which is due to the fact that epinephrine causes a constriction of the blood vessels at the site of the injection and thus delays absorption of the anæsthetic agent. There is also less bleeding as a result of this vasoconstriction. For each 200 cc of 0.5 per cent procaine solution 16 drops or 1 cc of a 1 to 2,600 solution of epinephrine is added.

With patients considered a good risk it is safe to use the following maximal amounts of procaine; 300 cc of 0.5 per cent solution; 100 cc of 1 per cent solution; 40 cc of 2 per cent solution.

Spinal anæsthesia.

This is a regional nerve block accomplished by injecting the solution into the spinal canal. Another special type of anæsthesia is *caudal block* in which the sacral nerves are anæesthetized by an injection of an anæsthetic solution into the sacral canal. Spinal anæsthesia will permit any operation from the level of the diaphragm downward, while caudal anæsthesia limits the field of operation to the structures supplied by the sacral nerves, the pelvic viscera, perineum, etc.

The drugs used for spinal anæsthesia are, in the order of choice: Procaine hydrochloride, metycaine hydrochloride, pontocaine hydrochloride, and nupercaine hydrochloride.

PROCAINE HYROCHLORIDE.—The dosage of procaine hydrochloride for spinal anæsthesia varies from 50 milligrams to 200 milligrams, the maximal dose. For

high abdominal operations 200 milligrams are dissolved in 3 cc to 6 cc of spinal fluid and injected into the spinal canal at the third or fourth lumbar intervertebral space. This will give an anæsthesia lasting about 1 hour. For operations on the lower abdomen 150 milligrams will suffice and 50 milligrams for short operations on the lower extremities.

METYCAINE HYDROCHLORIDE.—For spinal anæsthesia 75 milligrams of metycaine hydrochloride is equivalent to 100 milligrams of procaine hydrochloride. It is given interspinally the same as procaine with approximately 30 to 40 per cent longer duration of anæsthesia.

PONTOCAINE HYDROCHLORIDE.—This agent is obtainable in ampules containing 10 milligrams in crystal form for use in spinal anæsthesia. It is also available in ampules containing 2 cc of a 1 per cent solution representing 20 milligrams. The adult dose ranges from 5 milligrams to 20 milligrams. The usual site of injection is between the twelfth thoracic and first lumbar vertebræ. Anæsthesia lasts from 2 to 3 hours.

NUPERCAINE HYDROCHLORIDE.—For spinal anæsthesia a 1 to 1,500 solution is used. It produces long anæsthesia and is extremely potent and toxic.

GENERAL ANÆSTHESIA

General anæsthesia produces a state of unconsciousness associated with general loss of sensation, including, of course the loss of sensibility to pain. Usually the induction is by inhalation, but may be by intravenous or rectal administration of the anæsthetic agent. The principles governing the administration of general anæsthetic agents have advanced remarkably during recent years.

The trained anæsthetist is not satisfied with merely keeping his patient under the influence of the anæsthetic, as was formerly the practice, but endeavors to induce and maintain a light, even, surgical stage of anæsthesia during the entire operation. The various factors which influence the proper administration of the anæsthetic are discussed in more detail at the end of this section.

The anæsthetist is required in many instances to assume great responsibilities, and should acquire a thorough knowledge of the methods of anæsthesia and how to handle patients. In this connection it should be emphasized that patients awaiting operation frequently and needlessly are alarmed by a careless or thoughtless remark made by the attending hospital corpsman. This is especially true in the operating room during spinal anæsthesia and the early stages of general anæsthesia while the patient is still conscious. At such times his hearing is often very acute, and he is likely to hear conversation concerning his condition which might cause him needless anxiety and add to the risks of the operation.

The responsibility of the anæsthetist does not terminate upon completion of the operation. He is directly responsible for the patient during his transportation from the operating table to his bed and until properly relieved by a competent attendant.

Inhalation anæsthesia.

Inhalation anæsthesia is based upon the laws of diffusion of gases and vapors. During induction of anæsthesia the diffusion is from the lung alveolar air spaces to the blood and tissue cells, the direction of lessening partial pressure. Upon discontinuing anæsthesia the flow is reversed.

The main factors governing the efficiency and rapidity of anæsthesia are the potency of the agent, and the method of administration. These two

factors are responsible for anæsthetic concentration in the alveolar air and rapidity of diffusion through the alveolar membrane to the blood, which in turn carries the anæsthetic agent to the tissue cells, especially those of the brain. It is the saturation of the brain tissues with the anæsthetic agent which causes general anæsthesia. The rapidity with which an agent is absorbed by the brain tissues decides the rapidity of anæsthesia, and likewise the rapidity

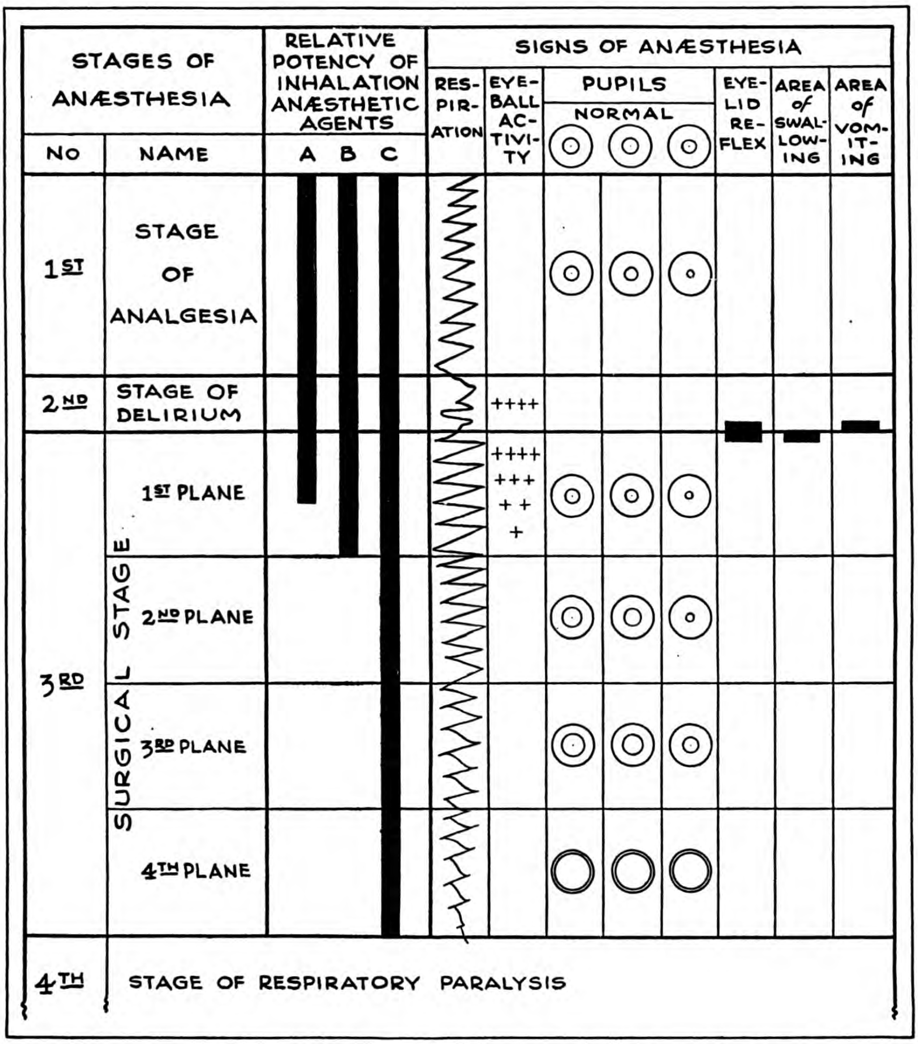

FIGURE 153.—Schema of inhalation anæsthesia (after Guedel).

of elimination by the brain tissues determines the speed of recovery from anæsthesia. It must be remembered that once the brain tissues become saturated sufficiently to produce anæsthesia it will take much less of the anæsthetic agent to keep the patient in this state.

STAGES OF INHALATION ANÆSTHESIA.—The four stages of inhalation anæsthesia are represented in Fig. 153. It also shows the relative duration of these stages which, according to Guedel, is constant with all inhalation anæsthetic agents.

The time required to carry anæsthesia through all stages by various agents, is as follows:

	minutes
Ether	10 to 30
Chloroform	4 to 12
Nitrous oxide	1 to 4
Ethylene	1 to 4
Ethyl chloride	1 to 4
Cyclopropane	½ to 3

This time is average and is flexible, depending on such conditions as age, risk group, etc.

First stage.—This lasts from the beginning of anæsthesia to the loss of consciousness. No attempt should be made to perform any operation in this stage. During this stage the respiration is normal until the approach of the second stage when it is increased. If during this stage respiration ceases it is due to the anæsthesia being forced. The patient is holding his breath, the result of laryngeal irritation. The pupils, with no preanæsthetic medication, will be dilated or normal depending upon the emotional reaction. If morphine has been given the pupils will be contracted. The eye-lid reflex is present. This reflex is elicited by raising the upper lid and upon being released it will close.

Second stage.—While this stage is short in duration it is the danger stage. Death may occur from physical injury or ventricular fibrillation and cardiac failure. Avoid all unnecessary external stimulation, such as handling the patient, loud talking, clatter of instruments and utensils, and surgical preparation of the field of the operation, etc. The patient should be well strapped to the table and not touched unless he attempts to fight the anæsthesia. It must also be remembered that the patient can become delirious emerging from the third stage to the second. The greatest eye-ball activity is in this stage, the extraocular muscles moving them back and forth.

Third stage.—This stage is divided into four planes and is the stage of surgical anæsthesia. In the FIRST PLANE of the third stage the respiration is rhythmic and full with an increase of volume. The eye-ball activity in this plane gradually diminishes and when it ceases the second plane is reached. Eccentric fixation of the eye-ball is sometimes present instead of the eye-ball activity, but as the second plane is approached the eye-ball returns to its normal position. When no preanæsthetic medication has been given the pupil returns to normal. The size of the pupil varies with preanæsthetic medication. The eye-lid reflex is absent. When the anæsthesia goes from the third stage to the second (patient coming out of anæsthesia), the swallowing reflex may become evident and precedes vomiting.

In the SECOND PLANE respiration remains the same and the pupil usually begins to dilate.

In the THIRD PLANE there is intercostal muscular paralysis and respiration becomes diaphragmatic. This can be detected by watching the thoracic movement or by placing a hand on the anterior thoracic wall. With complete intercostal paralysis there is no motion of the thorax, (lower part of third plane). Pupillary dilatation increases.

In the FOURTH PLANE respiration becomes shallow and the pupils completely dilated. Cyclopropane produces very little pupillary dilatation up to the fourth stage.

Fourth stage.—This is the stage of respiratory paralysis and failure and is followed by cardiac failure.

Open Drop Ether Technique.—Ether is dropped upon a wire mask covered with gauze which is held a few inches over the patient's face for a short period so as to accustom him to the odor. It is then placed over the nose and mouth and no attempt is made to further confine the vapor by wrapping the mask.

Guedel has worked out a very good system governing the amount of anæsthetic agent to be used which is as follows: "A fair guide to the dropping rate, which of course is only approximate, depends upon the size of the drops and the thickness of the gauze mask, is 12 drops the first minute 24 drops the second minute, 48 the third minute and 96 the fourth minute, doubling, each minute, the rate of the minute before. A rough guess of the percentage of ether vapor under the mask from this rate of dropping would be about one per cent the first minute; three per cent or four per cent the second minute; six per cent or seven per cent the third minute; and ten per cent or twelve per cent the fourth minute, which last figures represent approximately total saturation of the ordinary mask.

"It has been estimated that six per cent or seven per cent ether vapor under the mask is necessary for the maintenance of anæsthesia once it is established * * *.

"With the above rate of dropping of the ether the patient should pass into the second, or delirium stage of anæsthesia in about 4 minutes. The ether concentration inspired at that time is 10 per cent or 12 per cent, which is much higher than is necessary for maintenance. However, we must hold to this high concentration until we have driven the anæsthesia down to the desired stage * * *. It is impossible to figure the course of an anæsthesia mathematically, but we may estimate that complete saturation of the mask must be maintained from the fifth to the tenth minute after anæsthesia is started in an ordinary adult, and probably longer than this * * *. To summarizie the rate of ether administration, we may state that during the first 15 minutes it is carried as rapidly as possible to full saturation of the mask; about 100 drops per minute. During the second 15 minutes the rate is lowered to approximately 50 drops; during the third 15 minutes 20 or 30 drops and from this time on it is carried somewhere near the last figure. Again it is necessary to state that any estimate of the number of drops required or the percentages that exist under the gauze mask, cannot even approach accuracy. They are stated in this manner, only as a guide."

Semiclosed Method.—Is the same as the open drop method except that the mask is wrapped with towels, wet or dry, to prevent loss of anæsthetic vapor and retention of some of the expired carbon dioxide. By cutting down carbon dioxide depletion of the body the acid-base equilibrium of the blood is better maintained. Also the increase of carbon dioxide causes an increase in the amount of tidal air which with the higher concentration of anæsthetic agent will produce a faster induction of anæsthesia. The standard gas-oxygen ether machines used in the Navy give a semiclosed method of anæsthesia induction.

Closed Method.—This method necessitates the mask being tightly secured around the nose and mouth, thereby preventing any loss of anæsthetic agent. The accumulation of carbon dioxide is absorbed by soda-lime placed in a bypass between the breathing bag and anæsthetic mask. This can be cut in or out so as to regulate the carbon dioxide concentration. This feature was perfected by Waters and it allows the use of a minimal amount of agent and conserves the body heat and moisture. Special machines must be used for this method.

Drugs Used for Inhalation Anæsthesia.—*Nitrous oxide* (N_2O).—A colorless gas with a specific gravity of 1.527. It is not inflammable, but forms an

explosive mixture when combined with ether, ethylene, or oxygen. To be a good anæsthetic gas it should be not less than 95 per cent pure. To produce anæsthesia there must be a concentration of at least 80 per cent by volume. It produces no irritation to the respiratory tracts, and has about a 15 per cent potency. (*See* fig. 153.) Unless there is sufficient preanæsthetic sedation it will be difficult to carry the anæsthesia beyond the middle of the first plane, third stage. In attempting to obtain a deeper anæsthesia where there has been insufficient preanæsthetic medication given the oxygen content of the anæsthetic mixture is reduced. This reduction of oxygen, if continued, will produce anoxæmia and anoxia with a resulting acidosis. The closed method is employed and it can be used in the presence of a flame or cautery. It is applicable to operations of short duration and where deep anæsthesia with complete muscle relaxation is not essential. Nitrous oxide should be used with caution in the presence of high blood pressure, toxic goiter, and cardio-vascular disease. A trained anæsthetist only should administer it.

Ethylene **(C_2H_4).—**A colorless gas with a specific gravity of 0.8. It is inflammable and has a pungent odor and sweetish taste. Mixed with nitrous oxide it is highly explosive. Its potency is about 25 per cent, anæsthesia being carried to the lower border of the first plane in the third stage which is slightly more than nitrous oxide. It will permit the use of a higher percentage of oxygen to produce the same anæsthesia, hence there will be less chance of acidosis. It is administered by the semiclosed or closed carbon-dioxide-absorption method. As it is highly inflammable it should not be used in the presence of a cautery. Ethylene can be used for much the same conditions as nitrous oxide, and like the latter it does not give good muscular relaxation, although the relaxation is better than with nitrous oxide.

Cyclopropane **(C_3H_6).—**A colorless, inflammable gas, having a specific gravity of 1.46. It is supplied in cylinders and like nitrous oxide and ethylene is administered by the closed method. Its absorption and elimination by the body tissues is rapid, thus producing a rapid induction and recovery from anæsthesia. It is nonirritating to the respiratory tract and unlike the other inhalation anæsthetic agents it does not stimulate respiratory function. Cyclopropane has a 100 per cent potency and when administered produces similar physical signs to those of ether in the various stages of anæsthesia. There are not, however, the irritating effects that are present with ether in the first and second stages. It must be remembered that with cyclopropane there is but little pupillary dilatation. The depth of anæsthesia is governed by the depth of respiration.

Ether **($C_2H_5.O.C_2H_5$).—**A transparent, colorless, inflammable liquid which volatilizes at room temperature. Ether vapor is 2.6 times heavier than air and when mixed with oxygen, nitrous oxide or air it is explosive and inflammable. When ether contacts the skin and is covered with a towel, thus preventing evaporation, it will cause a burn. If dropped in the eye, it will produce conjunctivitis. It has a 100 per cent potency and can be given by the open, semiclosed, or closed method.

Chloroform **($CHCl_3$).—**A colorless liquid with a pleasant odor, the vapor being 4.1 times heavier than air. It is not explosive, and has an anæsthetic potency of 100 per cent. As it is highly toxic to the liver and the cardiovascular and nervous systems, and produces deep anæsthesia rapidly, it is considered an unsatisfactory anæsthetic agent. It is not inflammable but its heated vapor burns with a green flame, and care must be taken not to vaporize it in the presence of a naked flame because of the production of noxious gases.

Ethyl chloride ($CH_3.CH_2Cl$).—A colorless, inflammable liquid, the vapor being 2.2 times heavier than air. When sprayed on the skin it will freeze the superficial tissues, giving local anæsthesia. It can also be used for inhalation anæsthesia, but because of its being so volatile it is hard to maintain the anæsthetic levels. It is not recommended for inhalation anæsthesia.

Divinyl oxide ($CH_2 : CHOCH : CH_2$).—Known also as divinyl ether, vinyl ether, and vinethene. A colorless and inflammable liquid; it is given by the drop method. Induction and recovery are rapid, the absorption and elimination rate being twice that for ether. Physical signs of anæsthesia are practically the same as for ether. It is not recommended for long operative procedures. Further investigation must be made with respect to the value of divinyl oxide as an anæsthetic agent.

With the exception of nitrous oxide and chloroform these drugs are all inflammable and, with the exception of chloroform and ethyl chloride, all are explosive. Therefore great care must be taken to avoid using those that are inflammable or explosive, or are both, near an open flame such as is found in a lighted gas jet, lamp, burning candle, or stove, or in the vicinity of a hot cautery or electric spark. Carelessness in this respect has been the cause of many explosions and burning with fatal results. Electric sparks are the most common cause of explosions in anæsthesia, static sparks occurring within the anæsthetic apparatus or between the patient's face and the mask most frequently causing fatal explosions.

ADMINISTRATION OF THE ANÆSTHETIC IN INHALATION ANÆSTHESIA.—The choice of the anæsthetic to be used is left entirely to the medical officer in charge of the case, and is governed by the condition of the patient, the type of operation, the climatic conditions, and the type of agent available.

The hospital corpsman is particularly interested in the last two conditions. In very hot climates, as in the tropics, it is frequently next to impossible to induct general anæsthesia with ether, as it is so volatile that evaporation occurs almost immediately upon release from its container. Under such conditions it may be necessary to use chloroform. As nitrous oxide and ethyl chloride usually are not available in sufficient quantities outside of hospitals, dependence must be placed upon ether and chloroform. It is therefore essential that the hospital corpsman become thoroughly familiar with the administration of these two anæsthetic agents, especially the former.

Insufficient oxygenation of the blood is the cause of most of the difficulties in securing a quiet, peaceful, satisfactory anæsthesia, and of a large percentage of fatalities in connection with the use of anæsthetics.

The first important object, therefore, is to maintain a clear air passage in the patient. The anæsthetist should familiarize himself with the signs of obstructed breathing and should be able to recognize and overcome these obstructions as they occur. The most common causes of obstruction of the air passages are partial obstruction of the nasal passages, frequently found in otherwise normal individuals; the presence of mucus or vomitus in the mouth, pharynx, and naso-pharynx; firm closure of the jaws in the early stage of anæsthesia (patients with no teeth are prone to press their upper and lower gums together so firmly that very little or no air can enter); dropping of the lower jaw and "swallowing" of the tongue; position of patient with reference to mechanical pressure; spasm of the laryngeal muscles.

The only sure practice to follow in observing the patient's breathing is to hear or feel every respiration. As the patient's respiratory efforts continue for some time even though the air passages are obstructed, it is not enough that the

anæsthetist should only see the chest and abdominal movements; he must be certain that respiration actually is taking place.

Mucus or vomitus should be removed with a gauze sponge held in forceps. Dropping of the jaw and "swallowing" of the tongue should be overcome by light, even pressure under the jaw. In this connection it may be stated that long continued pressure over a small area of the jawbone may cause considerable soreness and tenderness for several days. It is occasionally necessary to hold the tongue forward by means of tongue forceps, although this procedure should be avoided if possible. Turning the patient's head to one side allows the drainage of mucus and other secretions and frequently prevents the backward drop of the tongue and jaw.

Laryngeal spasm usually is due to reflex action; a most frequent cause is too strong anæsthetic vapor. Withholding of the anæsthetic frequently will overcome the spasm. Impending vomiting with its resulting laryngeal spasm may be prevented by deepening the anæsthesia.

The question which naturally arises in each and every case is "How far is the patient under the influence of the anæsthetic?" It is essential that the anæsthetist know the exact degree of narcosis present at any and every given moment of anæsthesia. The requirements of the operation decide the depth of anæsthesia desired in each case. Constant practice in administering anæsthetics is necessary to obtain a knowledge of the finer details concerning general anæsthesia.

Induction of Ether Anæsthesia.—The open-drop technique of administering ether for general anæsthesia is considered the best as the amount of mucus secreted is generally much less, the tendency to coughing and labored breathing is decreased, the patient's color is better, and the pulse rate and blood pressure are well maintained. Most of the effects of deficient oxygenation of the blood do not occur, as this method permits the admixture of an adequate supply of oxygen from the air.

When the patient is in as comfortable a position as possible the face should be anointed with a bland ointment and the eyes covered with a layer of gauze. The mouth and nose then are covered either with one of several types of gauze mask or with three or four strips of gauze. It is best to allow the patient to breathe several times with the gauze in position in order that the patient may become accustomed to its presence and also to determine whether or not the thickness of the gauze is too great to permit free and easy respiration.

Before beginning the administration of the anæsthetic, which to some patients may be very disagreeable, it is frequently desirable to drop a few drops of oil of bitter orange peel on the gauze. This is then followed by the ether, which should be administered drop by drop, very slowly at first, then gradually increasing the amount until the patient can take the strongest vapor. The ether should be dropped over an area involving the mouth and nares. The patient should never be hurried and should never be advised to breathe deeply, as a feeling of suffocation will ensue and the patient is also likely to struggle. During the administration of the anæsthetic the anæsthetist should talk constantly to his patient in order to maintain the latter's confidence. In other words, the anæsthetist should talk his patient to sleep. By this method under ordinary conditions the patient can be brought under the influence of ether in from four to six minutes.

The four stages of inhalation anæsthesia with ether will next be described, omitting reference to the four planes of the third stage. 1. In the *stage of analgesia*, or light anæsthesia, occurs the primary decrease of consciousness

accompanied by a feeling of asphyxia and ringing in the ears. Respiration is accelerated; the blood pressure is increased slightly; the pulse becomes full and bounding; and the color of the skin becomes heightened. Concentrated vapor in this stage will cause coughing, holding of the breath, swallowing, spasm of the glottis, muscular rigidity, turning of head from side to side and slight dilatation of the pupils. 2. In the *stage of delirium*, or excitement, the controlling centers in the cerebrum are depressed and there is incoordination of movements and speech, which may amount to violent struggling and shouting. Memory, volition, and intelligence are interfered with; consciousness is partially or wholly lost; marked rigidity of muscles supervenes; the pupils are dilated and mobile; secretions of the respiratory tract are increased markedly; the face is very flushed; perspiration is evident and the breathing may be irregular. As the patient passes from this stage to the third stage, vomiting is not infrequent. Patients addicted to the use of alcoholic liquors frequently require a rather forced administration of the anæsthetic during this stage. 3. In the *stage of surgical anæsthesia* the cerebrum and spinal cord are paralyzed, sensation to pain is lost, and there is complete unconsciousness and relaxation. The respirations are deep, regular, and generally audible. A soft stertor may be considered normal. A strong stertor indicates obstruction of the air passage which requires immediate attention. The color of the face, ears, and lips is normal; the pupil is usually normal or contracted, but reacts to light; and the eyeball is eccentric or oscillatory. If the eyeball is stationary on center with pupil dilated, the patient is receiving too much ether, the administration of which should be discontinued at once. The lid reflex is weakly active; coughing and phonation are absent; and the heart action is accelerated. As anæsthesia progresses the face may become more flushed than normal. From the third stage the patient may change in the direction of consciousness or of deepening narcosis, the fourth stage. Returning consciousness is indicated by the following signs: Respiration regular, not full, but quiet; pallor of face; moderate dilatation of the pupils with light reflex; increased activity of lid reflex; swallowing movements; return of phonation. 4. The *stage of respiratory paralysis*, or dangerous stage, is the stage of overdose of the anæsthetic. The medulla oblongata becomes paralyzed and asphyxia and weakened circulation follow. Death occurs in this stage from paralysis of the respiratory center in the medulla. The signs of the fourth stage are weak, shallow respiration, cyanosis, soft feeble irregular pulse, dilatation of pupils with no reaction to light, absence of lid reflex, central fixation of eyeballs, separation of eyelids, and fall of blood pressure.

Treatment of Emergencies.—While every effort should be made to prevent the occurrence of emergencies, it is nevertheless true that, even in the hand of the most expert anæsthetists, various crises may occur which require immediate treatment. These emergencies or crises may be grouped under two headings, those due to respiratory failure and those due to circulatory failure. Reference already has been made to certain causes of respiratory obstruction and the indicated remedial measures have been discussed. The main effort in cases of respiratory failure should be directed toward clearance of the air passage and maintenance of the act of respiration. If the latter be not voluntary, artificial respiration is indicated. Regular pressure on the chest, drawing the tongue forward and lowering the head usually will restore normal breathing. If this procedure fails, it may be necessary to perform artificial respiration in accordance with the Sylvester method. Large amounts of fluid in the abdominal and pleural cavities may be the cause of respiratory embarrassment, and measures directed toward at least partial removal of these causes should be instituted.

The loss of the pupillary and corneal lid reflexes, associated with feeble respiration and increasing cyanosis, indicates paralysis of the respiratory center in the medulla. A hypodermic injection of atropine sulfate should be given immediately and artificial respiration instituted and continued until normal breathing is resumed. Anæmia of the brain, due to extensive hæmorrhage or to chloroform, is counteracted by lowering the head and raising the lower limbs if necessary.

Circulatory failure recognized by a running, feeble, or irregular pulse, increasing pallor, and feeble respirations must be overcome by stimulation of respiration as indicated above and by the administration hypodermically of cardiac stimulants (caffeine, epinephrine, etc.).

Any change in the general condition of the patient should be communicated immediately to the operating surgeon. The latter depends upon the anæsthetist to inform him concerning the progress of the anæsthesia, and the anæsthetist should not hesitate to institute whatever measures are indicated to promote a successful anæsthesia.

Intravenous anæsthesia.

The two anæsthetic agents commonly used in intravenous anæsthesia are: *Evipal soluble,* or *sodium cyclural,* (Sodium N-Methyl-cyclohexenyl-methylmalonylurea); and *Pentothal sodium* (Sodium ethyl (1-methyl butyl) thiobarbiturate). Both are derivatives of barbituric acid and are obtainable in ampules containing 15 grains (1 Gm.) each. The method of administration and the effects of both are the same, so the technique described herewith will apply to either. Pentothal sodium is the more potent of the two, requiring less dosage and giving more relaxation.

TECHNIQUE OF ADMINISTRATION.—The contents of one ampule (1 Gm.) is dissolved in 20 cc of triple-distilled sterile water making a 5 per cent solution. Each cubic centimeter of this solution contains ¾ grain of the agent. This is drawn up into a 20 cc syringe to which is attached a 20 gauge needle. A vein is selected, preferably in the arm, the skin is prepared and the arm draped. The vein is punctured with the needle and the solution injected slowly. At the time the injection is started the patient is told to count slowly and usually can only count to seven or ten before becoming anæsthetized. By this time (5 to 15 seconds) from 2 to 4 cc's have been injected. This will give from 15 to 30 minutes anæsthesia. To give further anæsthesia an additional 1 or 2 cc's of the solution is injected *after* the patient shows signs of recovering from first injection. Recovery is indicated by movements, deepening respiration, and increased muscle tone. The two things that must be maintained are unobstructed air passage and sufficient depth of respiration. Four cc's of the 5 per cent solution given rapidly can stop respiration, and 2 cc in the aged will produce the same bad effect.

Preliminary medication is the same for this type of anæsthesia as for others except that where the surgical procedure will last but a few minutes, the preanæsthetic medication can be omitted.

Rectal anæsthesia.

This type of anæsthesia, also known as colonic, is produced by the instillation of a drug into the rectum. The two commonly used drugs are avertin (tribromethanol ($CBr_3.CH_2OH$) dissolved in amylene hydrate) and ether and oil.

AVERTIN gives sedation simulating sleep but is not analgesic; therefore pain stimuli will arouse the patient. It depresses respiration and circulation but less postoperative medication is needed, and is safe for use in conjunction with other anæsthetic agents. Avertin is a white crystalline substance and

must not be exposed to sunlight or alcohol. Elimination is by the liver and to some extent by the kidneys. Anæsthesia with this agent will last from 1 to 4 hours, averaging 1½ hours. Following the period of anæsthesia the patient usually has a period of peaceful sleep lasting from 3 to 6 hours. It should be used with caution where there is evidence of disease of the kidney, liver or rectum.

The dosage is governed by the patient's weight and age and the solution prepared in accordance with a special table. It should be given only under the supervision of a medical officer.

Preparation of patient.—Give a cleansing enema, not soap-suds, the day before operation and a sedative the night before. Repeat the enema on the morning of operation. Preanæsthetic medication should be given 1 hour before operation. Following the operation any anæsthetic remaining in the rectum should be siphoned off and the rectum cleansed with 1 quart of warm water.

The anæsthetic tray should contain the following articles:

1. Large catheter.
2. Rubber tubing with connection for catheter.
3. Funnel to fit into tubing.
4. Special mixing flask and cork.
5. Large pan to hold hot water and flask.
6. Distilled water.
7. Thermometer (centigrade).
8. Graduate (cc).
9. Bottle of Congo red with dropper.
10. Lubricant.
11. Draw sheet (1); Towels (4).

In OIL-ETHER ANÆSTHESIA a combination of ether and olive oil is given rectally by means of rectal tube or large catheter and funnel. The systemic effect is the same as when ether is administered by inhalation. The mixture used consists of 6 fluidounces of ether and 2 fluidounces of olive oil which makes a 75 per cent mixture. The dose of this mixture is on the basis of 1 fluidounce to each 20 pounds of body weight, and a man weighing 140 pounds would therefore require 7 fluidounces. The patient is prepared the same as for avertin anæsthesia, except that the skin over the sacrum and perianal region must be protected with petrolatum for the oil-ether mixture is very irritating to the skin. The genitalia and inner aspect of the thighs must be well draped. At the finish of the operation any anæsthetic remaining in the rectum should be siphoned off and measured. Cleanse the rectum with 1 quart of warm water, and then instill about 100 cc of olive oil and allow it to remain.

The patient should have close supervision following both avertin and oil-ether anæsthesia, using the same precautions as are taken for ether inhalation anæsthesia.

The anæsthetic tray should contain the following articles:

1. Large catheter or rectal tube.
2. Funnel to fit catheter or rectal tube.
3. Bottle or container with tight-fitting top for mixing oil and ether.
4. Graduate.
5. Petrolatum.
6. Draw sheet.
7. Towels.
8. Clamp for rectal tube.

PREANÆSTHETIC MEDICATION

Preanæsthetic medication is important, as it allays the patient's fear and anxiety, thus giving him more nearly normal pulse, respiration and blood pressure, with a quiet induction, and thereby requiring less anæsthetic agent.

The night before operation a mild sedative, such as codeine or a barbiturate should be given to induce sleep.

On the day of operation further preanæsthetic medication with opium derivatives, solanaceous alkaloids, barbituric acid derivatives, etc. should be given.

Opium derivatives.

MORPHINE, the most commonly used of these derivatives, is an analgesic in small doses and a respiratory depressant in large doses. It should be given 1 to 1½ hours prior to operation, as there may be a mild stimulation during the first half-hour, and the greatest respiratory depression during the second half hour. The dosage used is ⅛ to ¼ grain.

Solanaceous alkaloids.

ATROPINE lessens the secretions of the respiratory tract and stimulates metabolism. Because of the metabolic stimulation it should not be given to toxic goiter cases. It is usually given combined with morphine in which form the usual dose is morphine ¼ grain and atropine 1/150 grain.

SCOPOLAMINE is given for its sedative action thereby inhibiting the emotional activity. It is often given in combination with morphine when there is obtained both sedative and analgesic action, the ordinary dosage in this form being morphine ¼ grain and scopolamine 1/100 grain.

Barbituric acid derivatives.

Of the many barbiturates available the most commonly used are *barbital, amytal, phenobarbital* and *pentobarbital* in the form of their more soluble sodium salts. They all act similarly as soporifics, affecting the intellectual centers with practically no analgesic action. They are synergetic in action with morphine, hence when used in combination with morphine there will be obtained cerebral sedation and analgesia. Barbital and phenobarbital are eliminated mostly by the kidneys, while amytal and pentobarbital are detoxified by the liver. Hence, with pathology in the kidneys, amytal and pentobarbital should be chosen. Likewise, with liver damage, barbital and phenobarbital are preferable.

Tribromethanol, or Avertin, is sometimes used as a preanæsthetic medication being given per rectum in doses of 60 mgm. per kilogram of body weight.

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CHAPTER XI

Section 1.—ADMINISTRATION AND GENERAL CLERICAL PROCEDURES

Upon the officers and enlisted men of the Hospital Corps the Medical Department of the Navy depends largely for the supervision and the performance of the clerical work required wherever there is a representative of the Medical Department on duty.

In the lower ratings the primary duty of hospital corpsmen concerns the care of the sick and the injured. As they advance in rating they necessarily become more familiar with the administrative and clerical duties in the Medical Department, and when assigned to such duties must assume responsibility not only for the accuracy of the work performed but also for sc organizing and supervising the clerical force that a maximum of efficiency will be obtained.

To satisfactorily perform these duties, hospital corpsmen must:

1. Be conversant with the Navy as regards its organization and personnel, its history, and the laws and regulations governing the Naval Establishment;
2. Be thoroughly familiar with the history and organization of the Medical Department, the laws and regulations governing its duties, the sources and application of monies under its control, and the relationship of the Medical Department to the Naval Establishment;
3. Have a full knowledge of the duties of the Medical Department ashore in naval hospitals and at other shore stations, and afloat on the various types of vessels composing the fleets; and
4. Understand office management and the Navy Regulations and bureau manuals governing the performance of clerical and administrative duties.

In this section much information that could well be included is omitted on account of lack of space and because it can be found in official publications that are easily accessible. For these reasons the information given here is more or less general in scope and must be supplemented by reference to other publications for detailed and specific information not found here.

THE NAVY DEPARTMENT, ITS BUREAUS AND OFFICES

Section 415 of the Revised Statutes of the United States provides that there shall be at the seat of government an executive department, to be known as the Department of the Navy, and a Secretary of the Navy, who shall be the head thereof.

The Navy Department is charged with the general control and administration of the Navy of the United States.

In section 2 of Article II of the Constitution of the United States of America it is provided that the President of the United States shall be the Commander in Chief of the Navy of the United States.

The Secretary of the Navy, a civil officer, is appointed by the President, by and with the advice and consent of the Senate of the United States, and because he is the head of an executive department is a member of the President's Cabinet. He performs such duties as the President may assign to him or are required by law and has the general superintendence of construction, manning, armament, equipment, and employment of vessels of war.

The Secretary's deputy is the Assistant Secretary of the Navy, a civil officer, whose appointment is authorized by law and who performs such duties as may be prescribed by the Secretary of the Navy or are required by law. In the absence of the Secretary of the Navy his duties are performed by the Assistant Secretary of the Navy.

In the temporary absence of the Secretary and the Assistant Secretary of the Navy, the Chief of Naval Operations is, by law, next in succession to act as Secretary of the Navy. In the absence of all three of those just named the duties of the Secretary of the Navy temporarily devolve upon line officers of the Navy in the following order of succession: Chief of the Bureau of Navigation, Chief of the Bureau of Ordnance, Chief of the Bureau of Engineering, Chief of the Bureau of Aeronautics, and the Judge Advocate General of the Navy.

For administrative purposes the Navy Department is divided into the Office of Naval Operations and eight bureaus, each charged with certain specific duties and in charge of an officer of the Navy appointed by the President, by and with the advice and consent of the Senate. These officers are appointed for 4 years and during their term of office have the rank of rear admiral except in the case of the Chief of Naval Operations who has the rank of admiral. In addition to the foregoing there are the Judge Advocate General of the Navy and the Major General Commandant of the Marine Corps. The Judge Advocate General is an officer of the Navy or the Marine Corps, appointed by the President for 4 years, by and with the advice and consent of the Senate, and while so serving has the rank of rear admiral in the Navy or of major general in the Marine Corps, as the case may be. The Major General Commandant of the Marine Corps is an officer of the Marine Corps appointed by the President for 4 years, by and with the advice and consent of the Senate, and while so serving has the rank of major general in the Marine Corps.

Following is a list of the eight bureaus of the Navy Department and the titles of the officers in charge of them:

Yards and Docks	Chief of the Bureau.
Navigation	Chief of the Bureau.
Ordnance	Chief of the Bureau.
Construction and Repair	Chief Constructor and Chief of the Bureau.
Engineering	Engineer in Chief and Chief of the Bureau.
Supplies and Accounts	Paymaster General and Chief of the Bureau.
Medicine and Surgery	Surgeon General and Chief of the Bureau.
Aeronautics	Chief of the Bureau.

The business of the Department of the Navy not specifically assigned by law is distributed among the bureaus and offices by the Secretary in such manner as he judges to be expedient and proper. The various duties performed under this distribution are, briefly, as follows:

Office of the Chief of Naval Operations.

Operations of the fleet and the preparation and readiness of plans for its use in war; direction of the Office of Naval Intelligence and the Division of Fleet Training; operation of the Communication Service, of naval districts, of Naval Reserve vessels, and of mines and mining; the operations of the Marine Corps, except when operating with the Army or on other detached duty by order of the President; the operations of Coast Guard vessels when operating with the Navy; the direction of all strategic and tactical matters, organization of the fleet, maneuvers, gunnery exercises, drills and exercises, and the training of the fleet for war; and the preparation, revision, and record of regulations for the government of the Navy, general orders, tactical instructions, drill books (except those issued for the individual instruction of officers and enlisted men), signal codes, and cipher codes.

Bureau of Yards and Docks.

The design, construction, alteration, and inspection of the public works and public utilities of the shore establishments of the Navy and (with certain exceptions) their repair and upkeep and administrative supervision of operation; the acquisition and disposition of real-estate and the custody of real property no longer needed for the use assigned, as provided in articles 426 and 427, U. S. Navy Regulations.

Bureau of Navigation.

The procurement, education, training, discipline, and distribution of officers and enlisted men of the Navy, Naval Reserve, and the Reserve Officers' Training Corps, except the professional education of officers, nurses, and enlisted men of the Medical Department; the supply, maintenance, and repair of ships' navigational outfits, including instruments; ocean and lake surveys and the collection of foreign surveys; the publication and supply of charts, sailing directions, and nautical works, and the collection and dissemination of all nautical, hydrographic, and meteorological information to ships and aircraft; the upkeep, operation, and repair (with certain exceptions) of the Naval Academy, Postgraduate School, Naval War College, training schools for enlisted men, training stations, Naval Home, Naval Observatory, and Hydrographic Office; the direction of receiving ships and stations; the issue, recording, and enforcement of orders of the Secretary of the Navy to officers of the Navy and of the Naval Reserve; the keeping of the records of service of officers and enlisted men; the preparation, revision, and enforcement of regulations governing uniforms; and naval discipline, rewards, and punishments.

Bureau of Ordnance.

The design, manufacture, procurement, maintenance, issue, and efficiency of all offensive and defensive arms and armament, and, unless otherwise excepted, optical and other devices and material for the control of guns, torpedoes, and bombs; the upkeep, operation, and repair (with certain exceptions) of naval gun factories, ordnance plants, torpedo stations, proving grounds, powder factories, ammunition depots, magazines on shore, and mine depots.

Bureau of Construction and Repair.

The general design, structural strength, stability, and seaworthiness of all ships of the Navy, except airships; the designing, building, fitting out, and repairing of hulls of vessels; preparation of plans and data showing designs

of new vessels; provision of facilities and arrangements for salvage of vessels; the drydocking of vessels and the operating and cleaning of drydocks and marine railways; the design, development and procurement of materials and appliances for gas defense; diving gear and experimental diving units, and respiratory protective devices; paravanes and mine-sweeping gear.

Bureau of Engineering.

The design, construction, installation, and maintenance of all propelling machinery, together with its auxiliaries, and, unless otherwise excepted, exterior and interior communication systems, electric wiring and cable, and auxiliary machinery; the design, manufacture, installation, and maintenance of all radio and sound equipage; the upkeep, operation, and repair (with certain exceptions) of the Engineering Experiment Station, Naval Research Laboratory, Naval Boiler Laboratory, and Material Laboratory (jointly with the Bureau of Construction and Repair); preparation of specifications for fuel.

Bureau of Supplies and Accounts.

The procurement, purchase, custody, shipment, warehousing, and sale of all supplies, fuel, and other property of the Navy (unless otherwise provided for and excepting supplies for the Marine Corps); the supply and disbursement of funds and the payment for articles and services procured for the Navy; the upkeep and operation of the Naval Clothing Factory and coffee-roasting plants; administrative supervision over fuel plants and commissary activities; authorization of transportation of Navy property and household effects of Navy personnel.

Bureau of Medicine and Surgery.

"The Bureau of Medicine and Surgery, under the direction of the Secretary of the Navy, is charged with and responsible for the maintenance of the health of the Navy, for the care of the sick and injured, for the custody and preservation of the records, accounts, and properties under its cognizance and pertaining to its duties, and for the professional education and training of officers, nurses, and enlisted men of the Medical Department of the Navy." (Art. 457 (1), N. R.)

"It is charged with the upkeep and operation of all naval hospitals, medical supply depots, medical laboratories, the Naval Medical School and of all technical schools established for the education or training of members of the Medical Corps, Dental Corps, Nurse Corps, and Hospital Corps, and with their repairs, except as excluded in article 484." (Art. 457 (2), N. R.)

"The Bureau of Medicine and Surgery shall provide for inspection of the sanitary condition of the Navy, shall recommend with respect to all questions connected with hygiene and sanitation affecting the service, and, to this end, shall have opportunity for necessary inspection; it shall advise with other bureaus and offices in reference to the sanitary features of ships under construction and in commission, regarding berthing, ventilation, and location of quarters for the care and treatment of the sick and injured; of the provisions for the care of wounded in battle; and, in the case of shore stations, with regard to health conditions depending on location, the hygienic construction and care of public buildings, especially of barracks and other habitations, such as camps. It shall also advise concerning matters pertaining to clothing and food, to water supplies used for drinking, cooking, and bathing purposes, and to drainage and disposal of wastes, so far as these affect the health of the Navy. It shall safeguard the personnel by the employment of the best methods of hygiene and sanitation, both afloat and ashore, with a view to maintaining

the highest possible percentage of the personnel ready for service at all times, and shall adopt for use all such devices or procedures as may be developed in the sciences of medicine and surgery as will in any way tend to an increase in military efficiency." (Art. 458 (1), N. R.)

"It shall be the duty of the Bureau of Medicine and Surgery to provide for the physical examination of officers, nurses, and enlisted men, with a view to the selection or retention of those only whose physical condition is such as to maintain or improve the military efficiency of the service if admitted or retained therein; and it shall pass upon the competency, from a professional standpoint, of all men of the Hospital Corps for enlistment, enrollment, and promotion by means of examinations conducted under its supervision or by such forms as it may prescribe." (Art. 458 (2), N. R.)

"The Bureau of Medicine and Surgery shall recommend to the Bureau of Navigation the complement of Medical Department personnel for hospitals and hospital ships, and shall recommend and have information as to the assignment and duties of medical officers, dental officers, and hospital corpsmen. It shall be charged with the administration of the Nurse Corps, and shall have power to appoint and remove all nurses, subject to the approval of the Secretary of the Navy." (Art. 458 (3), N. R.)

"It shall require for and have control of the preparation, inspection, reception, storage, care, custody, transfer, and issue of all supplies of every kind used in the Medical Department for its own purposes; and shall have charge of the civilian force employed at naval hospitals, medical supply depots, medical laboratories, the Naval Medical School, and at all technical schools for the education or training of Medical Department personnel." (Art. 458 (4), N. R.)

"It shall approve the design of hospital ships insofar as relates to their efficiency for the care of the sick and wounded, and shall provide for the organization and administration of the Medical Department of such vessels." (Art. 458 (5), N. R.)

"The arrangements for care, transportation, and burial of the dead shall be under the jurisdiction and control of the Bureau of Medicine and Surgery, except as otherwise provided in article 1841." (Art. 458 (6), N. R.)

Bureau of Aeronautics.

The design, construction, fitting out, testing, repair, and alteration of naval and Marine Corps aircraft and (with certain exceptions) instruments, equipment, and accessories pertaining thereto; the upkeep, operation, and repair (with certain exceptions) of all aeronautics shore establishments of the Navy and Marine Corps, exclusive of aircraft operations.

The Judge Advocate General of the Navy.

Shall have cognizance of all matters of law arising in the Navy Department; revise and report upon the legal features of and have recorded the proceedings of all courts-martial, courts of inquiry, boards of investigation and inquest, and boards for the examination of officers for retirement and promotion in the naval service; prepare charges and specifications for courts-martial, and the necessary orders convening courts-martial, courts of inquiry, and various examining boards when ordered by the Secretary of the Navy; prepare courts-martial orders promulgating final actions and other legal information; conduct all official correspondence relating to such courts and boards; examine and report upon all questions relating to rank and precedence, promotions and retirements, and the validity of the proceedings in court-martial cases, all matters relating to the supervision and control of naval prisons and prisoners, including prisoners of war; removal of the mark of desertion, correction of records of service of

naval personnel; certification of discharge in true name; pardons; interpretation of statutes; references to the General Accounting Office; proceedings in civil courts by or against the Government or its officers; preparation of advertisements, proposals, and contracts; insurance; patents; the sufficiency of official contracts, and other bonds and guarantees; claims by or against the Government; conduct correspondence respecting the foregoing, including preparation for submission to the Attorney General of all questions directed by the Secretary of the Navy to be so submitted; examine and report upon all Congressional bills and resolutions referred to the Navy Department; draft all proposed legislation arising in the Navy Department; examine and report on questions of international law; search titles, purchase, sale, transfer, and other questions affecting lands and buildings pertaining to the Navy; and care for and preserve all muniments of title to land acquired for naval uses.

The Major General Commandant of the Marine Corps.

The procurement, discharge, education, training, discipline, and distribution of officers and enlisted personnel of the Marine Corps, including the Marine Corps Reserve, and the administration and general efficiency of the Marine Corps and of the Marine Corps Reserve; the upkeep, operation, and repair (with certain exceptions) of marine barracks and marine posts.

THE NAVAL FORCES AND NAVAL STATIONS

Primarily, the Navy is the naval forces of the United States composed of the combatant forces of vessels, aircraft, and troops operating under naval authority together with such additional vessels, district craft, aircraft, or other units as may be assigned thereto for training, utilitarian, or other purposes.

The combatant forces are organized into fleets, forces, type organizations, flotillas, aircraft wings, aircraft groups, squadrons, and divisions. The vessels of the Navy are classified as battleships, cruisers, aircraft carriers, destroyers, mine layers, submarines, patrol vessels, and auxiliaries consisting of destroyer, submarine, aircraft, and seaplane tenders; repair, store, ammunition, and cargo ships; oilers; transports; mine sweepers; submarine rescue vessels; hospital ships; and tugs.

Although afloat, the vessels of the naval forces must place great dependence on shore stations for many repairs, for supplies and equipment, and for personnel so that the maximum of efficiency may be maintained. As a direct result of this dependence the Navy Department has under its control a number of naval stations both within and without the continental limits of the United States.

The United States and its possessions, with the exception of Guam, American Samoa, Puerto Rico, and the naval station at Guantanamo, are divided into naval districts within which are located naval bases, navy yards, and naval stations.

The following definitions from Navy Regulations clearly state the composition and object of naval bases and shore stations:

"A naval base is, generically, a center from which men-of-war can operate and be maintained, and may be of a permanent or temporary character, depending upon whether its constructed naval accommodations are of a fixed or transient nature." (Art. 2050 (a), N. R.)

"Naval bases are divided geographically into two classes, home bases and outlying bases, and these are themselves divided by their facilities into main bases, subsidiary bases, and bases for particular types of naval craft.

(Destroyer bases, submarine bases, aviation bases, etc.)." (Art. 2050 (b), N. R.)

"A main home base is one within the continental territory of the country, from which the fleet can operate at all times and which is designated to maintain the fleet in all respects, both in peace and war." (Art. 2050 (c) N. R.)

"A main outlying base is one without the continental limits of the country, having as many of the attributes of a main home base as practicable, and designed to be a strong point of support for the fleet and from which it can be maintained for limited periods in war." (Art 2050 (d), N. R.)

"A subsidiary base (home or outlying) is one that contains some of the fixed elements of the main base and which, while not capable of supporting and maintaining the whole fleet, may so care for portions of it." (Art. 2050 (e), N. R.)

"A destroyer, submarine, aviation, or other base for particular types of naval craft is one from which the type in question can operate and be maintained. It may or may not form part of a main or subsidiary base." (Art. 2050 (f), N. R.)

"An outlying base of a temporary character used in war for the fleet or portions of it is termed an advanced base." (Art. 2050 (g), N. R.)

"The characters, composition, and strength of naval bases will depend upon the necessities of service, at all times." (Art. 2050 (h), N. R.)

"A naval station is the location of a particular form of naval activity, and may or may not form part of a naval base." (Art. 2050 (i), N. R.)

"A naval depot is the location where naval personnel or material is stored and delivered, and may or may not form a part of a naval base." (Art 2050 (j), N. R.)

Navy yards are shore establishments, largely industrial in character, that are principally concerned with the repair, alteration, dry docking, and overhaul of naval vessels. Some are equipped for the construction of naval vessels and others for special kinds of work.

The following definitions of certain naval terms often used are from U. S. Navy Regulations:

"Strategy applies to the distribution of naval forces, their armament and supplies in preparation for war or in the prosecution of war. It includes logistics. It refers to naval movements and dispositions made before contact with the enemy's forces." (Art. 2051, N. R.)

"Tactics applies to all naval movements and operations made after contact with the enemy's forces. The term 'contact' is here employed in a broad sense, meaning such proximity to the enemy as affects fleet formation and renders a battle imminent." (Art. 2052, N. R.)

"Naval policy.—Everything that includes the fixed condition of preparation for war; that is, the strength, character, and composition of the Navy, fortification of ports and bases, etc. (This will be based upon our political relations and the probability of war with different powers. It will also be influenced by the conclusions of a comprehensive study of the political relations between other powers throughout the world and their influence upon coalitions and alliances.)" (Art. 2053, N. R.)

THE BUREAU OF MEDICINE AND SURGERY

From before the inception of the Government to August 31, 1842, the history of the medical department of the Navy is interwoven with that of other branches of the service.

In 1775 the Continental Congress organized the Navy. Thus it will be seen that the Navy has existed longer than the Government and was established

prior to the Declaration of Independence. Military control of the earliest vessels of the Navy was directly under the Continental Congress and was conducted through its naval committee.

Under the present form of government the executive department known as the Department of War was created by act of Congress in 1789. This department controlled the Navy as well as the Army. By the act of Congress of April 30, 1798, another executive department, denominated the Department of the Navy, was established. But the Navy Department was not divided into bureaus and consisted only of one office, whose head then, as now, was the Secretary of the Navy.

Each vessel of the Navy in those historical days carried at least one surgeon, and some of the larger ships a surgeon and surgeon's mate. Surgeons usually held commissions, and the surgeon's mates received warrants. These members of the medical profession serving in the Navy seem to have had little, if any, relationship to one another (which is not surprising when one realizes that at that time there was no medical corps and no organization in the Navy Department directly responsible for the supervision of them or their work), and their rank and status was not well defined.

The first attempt to regulate the medical establishment and provide a systematic organization occurred in 1799, when Congress authorized the following officers in the medical establishment of the United States: "A physician general who shall be charged with the superintendence and direction of all military hospitals, and generally of all medical and chirurgical practice or service concerning the Army or Navy of the United States, and of all persons who shall be employed in and about the same, in camps, garrisons, and hospitals; an apothecary general, and one or more deputies, who shall be charged with the safekeeping and delivery of all medicines, stores, and whatsoever else may be necessary in relation to said practice or service."

In 1815 Congress authorized the President to appoint three naval officers as a board of commissioners for the Navy, to be attached to the Secretary's office and, under his direction, to discharge the ministerial duties of his office. Here may be seen the first step toward the creation of the present day chiefs of bureaus. In 1832 two post captains were added to the board of commissioners for the Navy, making five members on the committee.

Then came the reorganization of the Navy Department, when by the act of August 31, 1842, the board of commissioners for the Navy was abolished and five bureaus were created to conduct the business of the Navy Department.

The Secretary of the Navy by this act was directed to assign the duties of the newly created bureaus in the following words: "Sec. 5. And be it further enacted, That the Secretary of the Navy shall assign and distribute among the said bureaus such of the duties of the Navy Department as he shall judge to be expedient and proper; and all the duties of the said bureaus shall be performed under the authority of the Secretary of the Navy, and their orders shall be considered as emanating from him and shall have full force and effect as such."

One of the bureaus created by this act, and by it responsible for conducting a part of the business of the Navy Department, was the Bureau of Medicine and Surgery, and its existence as a separate and distinct bureau in the Navy Department dates from August 31, 1842.

At that time there were 60 surgeons in the Navy and the first chief of the Bureau of Medicine and Surgery was selected from them. Upon the man so selected rested the burden of planning the organization of the newly created bureau, of developing a medical corps, of coordinating the activities of the sur-

geons and surgeon's mates, and other personnel, and formulating the necessary regulations to govern and control this branch of the Navy Department.

Viewed from the standpoint of later years it must be conceded that a wise selection was made in choosing as the first Chief of the Bureau of Medicine and Surgery, Surgeon William Paul Crillon Barton. By education, training, and naval experience he was peculiarly fitted to organize and administer the new bureau, and to him must be accorded full credit for the work which he performed under adverse and trying conditions in establishing the bureau upon a firm foundation.

Following is a list of the names of the chiefs of the Bureau of Medicine and Surgery and the Surgeons General, United States Navy, from 1842 to date:

Chief of Bureau. (Act of August 31, 1842.)

William Paul Crillon Barton	Sept. 2, 1842, to Apr. 1, 1844.
Thomas Harris	Apr. 1, 1844, to Sept. 30, 1853.
William Whelan	Oct. 1, 1853, to June 11, 1865.
Phineas J. Horwitz	July 1, 1865, to June 30, 1869.

Chief of Bureau, with relative rank and pay of commodore and title of Surgeon General. (Act of March 3, 1871.)

William Maxwell Wood	July 1, 1869, to Oct. 31, 1871.
Jonathan M. Foltz	Nov. 1, 1871, to June 8, 1872.
James C. Palmer	June 10, 1872, to July 8, 1873.
Joseph Beale	July 9, 1873, to Feb. 2, 1877.
William Grier	Feb. 3, 1877, to Oct. 5, 1878.
J. Winthrop Taylor	Oct. 28, 1878, to Aug. 19, 1879.
Philip S. Wales	Aug. 20, 1879, to Jan. 27, 1884.
Francis M. Gunnell	Apr. 1, 1884, to Apr. 1, 1888.
John Mills Browne	Apr. 2, 1888, to May 10, 1893.
James Rufus Tryon	May 11, 1893, to Sept. 7, 1897.
Newton L. Bates	Oct. 1, 1897, to Oct. 18, 1897.

Chief of Bureau, with the rank of rear admiral, title of Surgeon General, and pay and allowances of brigadier general in the Army. (Act of March 3, 1899.)

William Knickerbocker Van Reypen	Oct. 23, 1897, to Jan. 25, 1902.
Presley Marion Rixey	Feb. 5, 1902, to Feb. 4, 1910.
Charles Francis Stokes	Feb. 7, 1910, to Feb. 6, 1914.

Chief of Bureau, with the rank of rear admiral, title of Surgeon General, and pay and allowances of major general in the Army. (Act of July 1, 1918.)

William Clarence Braisted	Feb. 7, 1914, to Nov. 29, 1920.
Edward Rhodes Stitt	Nov. 30, 1920, to Nov. 29, 1928.
Charles Edward Riggs	Jan. 19, 1929, to Jan. 18, 1933.
Perceval Shearer Rossiter	Mar. 16, 1933, to Nov. 30, 1938.
Ross "T" McIntire	Dec. 1, 1938, (present incumbent).

The duties of the Bureau of Medicine and Surgery, as defined by the United States Navy Regulations, articles 457 and 458, are given on pages 752 and 753.

To carry out these duties, officers and enlisted men of the Medical Department of the Navy necessarily will be found wherever the activities of the Navy lead.

The primary duty of the medical department of the Navy is to preserve the Navy's personnel from impairment by reason of sickness or injury, and to return men so incapacitated to active duty in the shortest period consistent with circumstances. To accomplish this object more readily, naval hospitals have been established at the geographical points where concentration of naval activities occurs and the Bureau of Medicine and Surgery is charged with their upkeep and operation under the general charge and superintendence of the Secretary of the Navy. Officers and enlisted men of the Navy and Marine Corps, afloat and ashore, in need of hospital treatment are transferred to the naval hospital most convenient to the ship or station on which they are serving at the time. To provide hospital care for the personnel of the fleets when transfer to a naval hospital is not possible, modern hospital ships are available.

It is in naval hospitals that the medical department's utility as a conserving force of the personnel of the Navy becomes most apparent, where its sphere of usefulness is best demonstrated, and where all that pertains to the sick and injured finds its fullest development.

The naval hospitals controlled by the Bureau of Medicine and Surgery and at present in commission are located at: Portsmouth, N. H.; Chelsea, Mass.; Newport, R. I.; New York, N. Y.; Philadelphia, Pa.; Annapolis, Md.; Washington, D. C.; Norfolk, Va.; Parris Island, S. C.; Charleston, S. C.; Pensacola, Fla.; Great Lakes, Ill.; San Diego, Calif.; Mare Island, Calif.; Puget Sound, Wash.; Pearl Harbor, Hawaii; Guam; and Canacao, P. I. In addition to the above naval hospitals, at the submarine bases at New London, Conn., and Coco Solo, C. Z., at the Marine Barracks, Quantico, Va., and at the naval stations, Guantanamo Bay, Cuba, and Tutuila, Samoa, establishments commonly known as sick quarters provide for the care of the sick and injured at these places in a manner similar to naval hospitals.

The naval hospitals at Brooklyn, N. Y., and San Diego, Calif., are designated for the treatment of cases of malignant diseases.

In addition to the hospitals directly under the cognizance of the Bureau of Medicine and Surgery there are special hospitals at which Navy and Marine Corps patients may receive treatment. One is the Army and Navy General Hospital at Hot Springs, Ark., where relief reasonably may be expected for the various forms of rheumatism, including muscular and articular conditions, after the acute inflammatory stage has passed; neuralgia and neuritis and metallic poisoning of a chronic nature; paralysis not of central origin; the earliest stages of locomotor ataxia and any other chronic degenerative change of nervous origin (insanity excepted); chronic nephritis and cardiorenal diseases (the early stages only); chronic skin diseases, especially the squamous varieties; arteriosclerosis; neurasthenic conditions, due to overwork, and other conditions accompanied by high blood pressure; certain metabolic diseases, such as gout, diabetes, obesity, etc.; chronic gastro-intestinal diseases which have not responded to continued hospitalization at other places (gastric neuroses, post dysenteric colitis, chronic intestinal stasis, etc.). In Fitzsimons General Hospital, United States Army, at Denver, Colorado, cases of pulmonary tuberculosis may receive treatment. Insane cases are cared for at St. Elizabeths Hospital, Washington, D. C. (formerly known as the Government Hospital for the Insane). At Philadelphia, Pa., "a permanent asylum for disabled and decrepit Navy officers, seamen, and marines" has been established and is known as the United States Naval Home. Officers of the Navy or Marine Corps may be admitted to the benefits of the Naval Home by permission of the Secretary of the Navy. Enlisted men of the Navy or Marine Corps may be admitted to the benefits of

the Naval Home by authority of the Bureau of Navigation under the following classification:

(A) Discharged enlisted men of the Navy or Marine Corps who have served in the Mexican War, the Civil War, the War with Spain, the Philippine Insurrection, the World War, or any other service where the armed forces of the United States have been employed, and their lives hazarded in military operations, and who are, by reason of wounds, sickness, old age, or other disability, unable to support themselves by manual labor.

(B) Discharged enlisted men of the Navy or Marine Corps who have become disqualified for further service by wounds, or injuries received, or by disease contracted in the service in the line of duty and who are unable to support themselves by manual labor.

(C) Retired enlisted men of the Navy and Marine Corps unable to support themselves by manual labor.

Applicants for admission to the Naval Home must be certified by a naval medical officer or a reputable physician as unable to support themselves by manual labor. Beneficiaries in the Naval Home are quartered in separate rooms, are outfitted with the necessary uniform and such other clothing as may be deemed necessary upon admission, are issued such items of clothing quarterly as may be required for health and comfort, are given 1½ pounds of tobacco per month, and when not in receipt of a pension are given an allowance of $3 per month for pocket money.

When naval hospitals are not convenient, United States Army Hospitals, the hospitals of the United States Public Health Service, and the facilities of the Veterans' Administration are available for the treatment of the Navy's sick, and in emergency patients may be transferred to a civil hospital, as provided for by article 1143, United States Navy Regulations.

The Surgeon General of the Navy is the Chief of the Bureau of Medicine and Surgery and its administrative head. Upon him devolves the formation of general policies and the maintenance of contact with:

(*a*) The medical divisions of the fleets through the fleet surgeons;

(*b*) The medical departments of naval stations through the senior medical officers; and

(*c*) Naval hospitals, naval medical supply depots, naval medical and Hospital Corps schools, and separate naval dispensaries or sick quarters through their commanding or senior medical officers.

The assistant to the chief of the bureau, a naval medical officer, acts as the executive, has general supervision of the entire organization and work of the bureau, assists in the development of general policies, and in the absence of the Surgeon General becomes the acting chief of the bureau and signs all mail or official correspondence.

The chief clerk has general supervision of the operation of the various bureau offices and becomes the acting chief of the bureau in the absence of both the chief of the bureau and the assistant to the chief of the bureau.

For ease of administration and to facilitate the transaction of business, the bureau is divided into the following divisions: Administration, Personnel, Dentistry, Physical Qualifications, Preventive Medicine, Aviation Medicine, Matériel and Finance, Inspections, Planning, Publications, and Red Cross and Veterans' Administration. The duties assigned to each are indicated by the titles.

MEDICAL DEPARTMENT PERSONNEL

Comprising the personnel of the medical department are the members of four corps, the Medical, Dental, Hospital, and Nurse Corps. The Medical Corps

is composed of medical officers, the Dental Corps of dental officers, the Hospital Corps of commissioned warrant officers, warrant officers, and enlisted men, and the Nurse Corps of trained nurses.

Medical and dental officers and nurses are appointed from civil life, the former by the President, by and with the advice and consent of the Senate, the latter by the Surgeon General with the approval of the Secretary of the Navy. Hospital corpsmen are enlisted or change their rating from other branches of the service to Hospital Corps ratings. Pharmacists (warrant officers) are appointed from chief pharmacist's mates (enlisted men) by the Secretary of the Navy and chief pharmacists (commissioned warrant officers) are appointed to that grade from pharmacists, being appointed by the President, by and with the advice and consent of the Senate.

For full information concerning the grades and ratings, appointments, promotions, and advancements, and the duties of the members of these corps, reference should be made to chapters 2 to 10, inclusive, and sections 2 to 4, inclusive, of chapter 12, Manual of the Medical Department.

NAVAL HOSPITALS

Legally, the title "naval hospital" can be applied only to those naval medical activities established as naval hospitals by order of the Secretary of the Navy prior to March 4, 1913, or authorized by act of Congress since that date. However, field hospitals and Navy base hospitals for foreign duty may, by competent authority, be classified as naval hospitals. All other medical facilities can be designated as dispensaries.

The advancement made in hospital construction reflects itself in the many types of architecture found in naval hospitals.

In addition to the main or hospital building, each hospital is equipped with other buildings necessary for the proper maintenance of the hospital, such as quarters for staff, power plant, laundry, garage, etc.

To carry out the principal "mission" of naval hospitals the duties performed by Medical Department personnel will be found to be of two kinds, professional or clinical and administrative. Professional duties are those primarily connected with the medical, surgical, dental, and nursing services. Each of these services is in charge of medical-department personnel designated by the commanding officer as Chief of Medical, Surgical, or Dental Service, and Chief Nurse. Under supervision of the Chief of Medical Service are the services of general medicine, psychiatry, laboratories, physical therapy, and out-patient; under supervision of the Chief of Surgical Service are the services of general surgery, eye, ear, nose, and throat, X-ray, urology, and orthopedics. The Chief of Dental Service has supervision of all dental work, and the Chief Nurse of all nursing. Administrative duties are those which concern organization, discipline, and training, maintenance and repair, preparation and preservation of records, preparation and serving of foods, procurement, custody, and disposition of property, etc. The commanding and executive officers are directly in charge of organization, discipline, and training, and the other administrative duties named, under their supervision, are directly in charge of naval pharmacists.

Naval hospitals are commanded by an officer of the Medical Corps of the United States Navy, usually of the rank of captain, who is responsible to the Bureau of Medicine and Surgery for the care and treatment of the patients and for the discipline, cleanliness, and economic management of the institution, and in turn exacts from subordinates, employees, and patients a proper obedience to his orders and to the laws and regulations of the Navy. All persons be-

longing to the Navy or Marine Corps who may be attached to the hospital or civilian employees in the hospital perform such duties as may be assigned them by the commanding officer. The general policies regarding the administration of naval hospitals are formulated in the Navy Department, but the commanding officer is responsible to the Bureau of Medicine and Surgery for the accomplishment of those policies in such manner as he may deem most suitable to local conditions. The general orders regarding the operation of a naval hospital are in the main very similar at all institutions, as they are governed by the policies of the Navy Department; but the working details of these policies differ at the various hospitals, due to location, capacity, arrangement, etc. The policies of the Bureau of Medicine and Surgery and the Navy Department are sufficiently flexible to allow for these varying conditions, over which the commanding officer is given complete control.

The medical officer next in rank to the commanding officer, unless otherwise ordered by the Navy Department, performs the duties of executive officer of the hospital. He is responsible to the commanding officer for the general functioning of the institution. The orders issued by the executive officer are the orders of the commanding officer, and therefore he always is well informed concerning the orders and policies of the commanding officer. Subject to the approval of the commanding officer, the executive officer directs all matters as regards duty assigned to personnel, discipline, leave, liberty, cleanliness, good order, etc. of the hospital. As he is the direct representative of the commanding officer, all requests or communications of any nature intended for the commanding officer must be taken up with him before being submitted to the commanding officer. Military etiquette demands that permission be obtained from the executive officer to communicate directly with the commanding officer. This is done in order that the executive officer may be informed regarding all matters pertinent to his office and at times relieve the commanding officer of minor details which can be adjusted by him. In the absence of the commanding officer, the executive officer is recognized as the commanding officer and performs such duty during his absence.

All medical officers attached to a naval hospital, other than those just mentioned, are commonly designated as junior medical officers. They are assigned to the various activities of the hospital by the executive officer with the approval of the commanding officer. The assignment of these officers to duty in the wards, operating room, X-ray department, laboratory, etc., places them in charge of work performed within the activity concerned, and they are directly responsible for the proper performance of their duties, and in turn exact of the hospital corpsmen and nurses under them strict attention to duty and proper performance of all orders issued by the commanding officer. The junior medical officers alternate in duty as officer of the day. An officer so acting is the representative of the commanding officer and is responsible to him for compliance with orders and the maintenance of good order and discipline in the hospital. If the commanding officer and executive officer be absent from the hospital, he is responsible for the efficient management of the hospital and during their absence has the authority necessary for the enforcement of the orders and regulations governing the hospital. In the absence of an officer assigned as ward officer, the officer of the day is charged with the proper care of the sick in the ward concerned, and all information regarding patients which under ordinary conditions would be taken up with the ward officer, is communicated to the officer of the day, who issues orders accordingly. Hospital corpsmen take up all matters pertaining to the treatment of patients directly with the medical officer of the ward, or in his absence the officer of the day, and all details

regarding patients, liberty, leave, work, etc., must be approved by the ward officer before being submitted to the executive officer. All patients admitted to a naval hospital are received by the officer of the day or his representative; he also is informed of all discharges involving patients; and all attachments, transfers, or discharges of staff must pass through his hands.

The replenishment of supplies, the upkeep, expenditure, accountability, and survey of property, management of the commissary department, and the correspondence and clerical work of the administrative offices of a naval hospital are duties performed by chief pharmacists and pharmacists. However, the commanding officer may direct that these officers perform other duties than those mentioned here. In order to accomplish this work, hospital corpsmen and civilian clerks are detailed in the offices concerned, under the direct charge of the chief pharmacist or pharmacist. In connection with the accountability of property great care has to be exercised at all times by hospital corpsmen, as it must be remembered that all equipment and supplies of the medical department are Government property and the laws governing their care and preservation are stringent and binding.

Hospital corpsmen may be detailed for duty in any activity of the hospital as the commanding officer may direct. As it is the policy of the Bureau of Medicine and Surgery that hospital corpsmen's duty shall be such as pertains directly with the care of the sick, all hospital corpsmen on duty in a naval hospital should thoroughly acquaint themselves with the orders and regulations governing the hospital, in order that they can carry out faithfully such duties as may be assigned them and all instructions concerning the treatment of patients consigned to their care be conscientiously accomplished. A chief pharmacist's mate customarily is detailed for duty as police petty officer of the hospital. He is responsible to the executive officer, and in his absence to the officer of the day, for such duties as may have been assigned him by the executive officer as regards the maintenance of discipline and order in the hospital and the various utility buildings of the hospital. Though the duties of a hospital corpsman at naval hospitals may, at times, seem disagreeable, such duties are often most important from a nursing standpoint, and the accomplishment of such duties in the manner directed by the medical officer concerned will make much for the efficiency of the hospital and will be recognized only as part of that intricate machinery called management.

Under direction of the commanding and executive officers the nursing service of a naval hospital is under the direct supervision of the chief nurse. She instructs nurses in their duties, particularly as they pertain to the naval service, and sees that the orders of the executive officer and ward officers are carried out by the nurses under her. Nurses in charge of wards, operating rooms, diet kitchens, or linen rooms are given the necessary authority over patients and hospital corpsmen for the purpose of directing the care of the sick and ward or other work. They are held responsible for their conduct, attention to duty, and practical instruction in the details assigned to them. The work assigned hospital corpsmen in naval hospitals is considered as a training for the work to follow when they are assigned to duty on board men-of-war and on independent duty, when the instructions obtained in the hospital will be fully appreciated.

The hospital has various special departments, such as dispensary, linen room, diet kitchen, etc., which are indirectly concerned in the treatment of the sick but are necessary adjuncts to the hospital. These departments are in direct charge of a nurse or hospital corpsman, who is responsible to the executive officer for the proper performance of duty as directed by the commanding officer.

U. S. NAVAL MEDICAL CENTER

The Naval Medical Center, established by General Order No. 70, dated June 20, 1935, at Washington, D. C., consists of the Naval Medical School and the Naval Hospital, Washington, D. C. It is under the control of the Bureau of Medicine and Surgery, and functions as a medical, diagnostic, and educational center. Each unit of the Naval Medical Center has its own commanding officer.

At the Naval Medical School postgraduate education is given medical officers and dental officers, and nurses and hospital corpsmen receive technical training in various subjects.

U. S. NAVAL DISPENSARY, WASHINGTON, D. C.

The Naval Dispensary provides treatment for naval personnel attached to the Navy Department and their families, renders first-aid treatment and care to the civil employees of the Navy Department, and conducts special physical and other examinations.

U. S. NAVAL MEDICAL SUPPLY DEPOTS

Three naval medical supply depots are maintained. The central depot is located at Brooklyn, N. Y., one at the Navy Yard, Mare Island, Calif., and one at Canacao, P. I. The central depot contracts for and purchases all supplies listed on the supply table and such other special equipment as may be required. It supplies the other depots with stock, also all shore stations on the Atlantic seaboard, and all ships operating in European, Atlantic, and South Atlantic waters. Mare Island supplies the shore stations on the west coast and ships in Pacific waters. Canacao supplies all ships and shore establishments in Asiatic waters.

The medical supply depots are separate commands for officers of the Medical Corps. The staff usually consists of one or more chief pharmacists or pharmacists, hospital corpsmen, and civil employees.

HOSPITAL CORPS SCHOOLS

Two schools are maintained for the instruction of hospital corpsmen, one at the Norfolk Naval Hospital, Portsmouth, Va., and one at the Naval Hospital, San Diego, Calif.

The commanding officers of these hospitals are also the commanding officers of the respective schools. The teaching staff consists of medical officers, chief pharmacists, pharmacists, and members of the Hospital Corps and Nurse Corps.

CLERICAL WORK IN THE MEDICAL DEPARTMENT OF THE NAVY

The clerical work in the medical department of the Navy required of hospital corpsmen may be explained most advantageously if separated into three divisions, as 1. General correspondence, i. e., letters, endorsements, etc.; 2. Requisition and voucher forms for the procurement of supplies and services; and 3. Reports and returns other than requisition and voucher forms.

Correspondence.

Correspondence or written communication in the Navy is divided into three general classes, which are official, semiofficial, and unofficial.

(*a*) Official correspondence is communication between officers of the Navy and the offices and bureaus of the Navy Department, commanders in chief,

commandants, vessels of the Navy, naval stations, ships and stations, and with other executive departments by the office of the Secretary of the Navy. The subject matter usually embraces information concerning the activities, duties, and policies of the Navy, recommendations, reports, and knowledge of conditions in foreign countries which are of value to the transaction of public business.

(*b*) Semiofficial correspondence usually is the communication of information in a partly official manner to a bureau or office in the Navy Department by officers under the direct cognizance of that bureau or office.

(*c*) Unofficial correspondence is all communication not considered official or semiofficial.

Official correspondence and information relating to any matter of such nature that special precautions should be taken to insure that information concerning it shall be permanently or temporarily limited in circulation is classified as *secret*, *confidential*, or *restricted*, and is defined as follows:

Secret matter is matter of such a nature that its disclosure might endanger the national security, or cause serious injury to the interests or prestige of the Nation or any Government activity thereof.

Confidential matter is matter of such a nature that its disclosure, while not endangering the national security, would be prejudicial to the interests or prestige of the Nation or any Government activity thereof.

Restricted matter is matter of such a nature that its disclosure should be limited for reasons of administrative privacy; or, is matter not classified as *confidential* because the benefits to be gained by a lower classification outweigh the value of the additional security obtainable from the higher classification.

Correspondence or information relating to methods of procedure regularly followed and to other subjects, a full knowledge of which could by no possibility be of use to an enemy is not considered as classified matter, constitutes a large part of correspondence, and is sometimes termed nonconfidential.

Official correspondence within the naval service is carried on in the manner prescribed in detail by the Navy Regulations. While the substance of official correspondence concerning the medical department of the Navy is determined by the officers charged with such duty, its transcription into official form for signature and forwarding usually is entrusted to hospital corpsmen. For one preparing correspondence, it is most important to remember to keep a copy of every letter or endorsement prepared and to have a systematic method of numbering and filing all such papers, so that they can be referred to readily.

A hospital corpsman detailed to perform clerical work should have access to a copy of the Navy Regulations, and the instructions in Chapter 52 thereof should be referred to whenever there is any doubt as to the proper form to be used or the method of procedure to be followed. In this section will be described only so much of the official instructions as will make clear the essential features of service correspondence by letter or endorsement.

Correspondence must be courteous in tone and free from expressions of a personal nature, but courtesy shall be indicated by the substance and feeling rather than by artificially polite phrases and formulas.

So far as is possible, and with due consideration of the public interests, the number of letters written and their length should be minimized. Accuracy, simplicity, and conciseness, especially in official correspondence, and confining letters to the one subject at hand without omitting necessary details and arranging the paragraphs of letters in logical sequence is most essential. If

adding to the clearness of a letter, the use of accompanying diagrams, tables, and sketches is permissible, but they should never be embodied in the letter.

Communications from subordinates are sent to their superior officers for transmittal. If in proper form and language, the superior officer forwards them as soon after receipt as practicable, stating thereon in writing, by endorsement or otherwise, his opinion in relation to every part of the subject contained in the communication.

To such papers as are complete in themselves and do not require an expression of opinion from the office through which they are transmitted, the term "forwarded" may be affixed and such papers transmitted under the endorsement of an officer of the staff, by direction of the commander in chief, the commandant, or the senior officer present.

As a general rule, letters shall be answered by letters and not by endorsement. This does not prevent the use of stamped or written endorsements on papers or reports copies of which are not retained, or the use of endorsements on papers necessarily referred to several bureaus or offices. This is intended to prevent unnecessary clerical work. When the original is answered by a separate letter each office has a complete record of the correspondence without extra work. Separate letters shall be written on separate subjects unless the subjects are of a like nature. The subject matter in a letter should be divided into paragraphs in logical sequence, each containing statements complete in themselves but all relative and pertinent to the subject at hand, and the paragraphs numbered.

All communications, except such as require neither action nor reply, shall be acknowledged.

Letters and endorsements shall be numbered and shall be typewritten if practicable, using noncopying ribbons and making a sufficient number of carbon copies for filing or other purposes. If correspondence cannot be typewritten, it should be written legibly and contain no erasures or interlineations. Carbon copies shall show the office of origin and the name of the signing officer shall be typewritten or stamped on all copies. In preparing letters, endorsements, and reports which go through another office or other offices, the office preparing the original will make on thin white paper a copy for each office through which the correspondence is to pass before it reaches its final destination. These copies will be marked for the appropriate office.

Letter paper habitually is used for official correspondence in the Navy, whether letters or endorsements. For the original or first copy, it is white linen typewriter paper, 8 by 10½ inches in size, weighing approximately 4½ pounds per ream of 500 sheets of that size. For file copies, a green tinted paper of the same size and weighing about 3 pounds per ream is used. Thin paper other than green is used for additional carbon copies.

Typewriter cap, used only in special cases, shall be 8 by 13 inches in size, but otherwise similar to letter paper.

The paper used for letters and endorsements has two holes punched in it, the center of the holes one-half inch from the top of the sheet and 2¾ inches apart and equidistant from the center of the sheet. These holes permit the sheets to be fastened together uniformly.

The following instructions relative to correspondence are quoted in full from article 2015, of U. S. Navy Regulations in order that they may be available for those who may not have ready access to a copy of that publication.

"(1) The forms prescribed in this article shall apply to all correspondence within the naval service, with the State naval militia organizations, and with

such departments as may adopt a similar form of correspondence, but not with departments, officials, and persons that have not adopted these or similar forms.

"(2) Letters shall begin with the ship or station, place and date, grouped and spaced as indicated in the examples in paragraph 27. The upper line of the heading shall be at least 1½ inches from the top of the page. In the case of endorsements which start on a new page, or any letter or endorsement continued on a new page, there shall also be left clear at least 1½ inches at the top for binding purposes.

"(3) The official designation of all vessels of the Navy shall be the name of the vessel preceded by the letters U. S. S. The word flagship shall follow the name of the vessel in the heading of a communication emanating from the office of a flag officer.

"(4) Special subletterheads may be used at shore stations to designate the different offices of the station, and by officers on detached duty ashore, but shall not be used to designate the different heads of departments on board ship. (See Example B and the last two examples under C.)

"(5) In communications dated on board a vessel at sea, the latitude and longitude shall be stated if exactness be necessary, otherwise the expression 'Passage, ------------ to ------------' shall be used.

"(6) Following the heading and date in letters and endorsements either the official designation, or the name and rank of the writer preceded by the word 'From', shall be written at the left side of the page as indicated in examples in paragraph 27.

"(7) On the line below 'From', and preceded by 'To' at the left of the page, shall appear the official designation of the office or official addressed; following this the channel through which the communication is to pass; these offices to be designated by numerals indicating the sequence of routing.

"(8) Following the address, the subject of the correspondence, briefed, shall be written across the page, preceded by 'Subject'.

"(9) The brief of the subject should be written in about the same form and terms as would be used in indexing the communication in filing; for example, '*Delaware;* feed pumps; recommends change in type', 'Navy Yard, New York; Dry-dock No. 1; reports damage to caisson struck by tug'.

"(10) The subject shall not be repeated at the beginning of an endorsement, except when required by the filing system of the writer's office to identify the file copy, or when the endorsement begins on a new sheet, in which case it shall always be repeated.

"(11) After the subject the references to previous correspondence on the same subject, if any, shall be briefly indicated, preceded by 'Reference'. Usually the references have been addressed either to the writer or to the addressee of correspondence, and it is necessary to indicate only the office of origin in references. Occasionally for clearness it is desirable to indicate the addressee of a referenced letter as shown in the form in paragraph 27.

"(12) In acknowledging, answering, or referring to official communications, the file number (letters as well as figures), and date shall be included in the 'Reference.' References shall be lettered in small letters, and may be referred to in the communication as 'Reference (a)', etc.

"(13) When a plan that has been given a file number is referred to in the correspondence, this number should be stated in connection with such reference.

"(14) Following 'Reference', if any, the number of enclosures shall be stated preceded by 'Enclosure' at the left of the page, as indicated in the example in paragraph 27.

"(15) The use of numbered enclosure slips attached to the enclosures is authorized, and in case they are used the serial number of the slip or slips should be given after the word 'Enclosures'. (See example B.)

"(16) Where necessary the method of forwarding enclosures, whether enclosed under separate cover or by express, shall be indicated. The absence of 'Reference' or 'Enclosure' will indicate that no reference or enclosure accompanies the communication.

"(17) The file number of the letter or endorsement shall be placed in the upper left corner, about 1 inch from top and 1 inch from the left edge of the page; the abbreviation or initials of the section or division preparing the correspondence to follow on the same line as the file number.

"(18) The body of letters and endorsements shall be written single spaced, with one double space between paragraphs. Each endorsement shall, where possible, be written on the same sheet as the preceding letter or endorsement, with a space of about one-half inch intervening.

"(19) Paragraphs in letters and endorsements, or other official papers, shall be numbered. Subparagraphs shall be lettered thus: (*a*), (*b*), etc.

"(20) The body of the letter shall begin and end without any ceremonial form or expression, such as 'Sir,' 'I have the honor to report', 'Very respectfully', etc., and shall be followed by the signature of the writer without designation of rank, title, or office. Information will be imparted, reports made, and questions asked directly, dispensing with such introductory phrases as 'The bureau informs you that', 'Information is requested as to', 'It is directed', etc.

"(21) In the body of the letter U. S. Navy shall be abbreviated to U. S. N., U. S. Naval Reserve to U. S. N. R., U. S. Marine Corps to U. S. M. C., and U. S. Marine Corps Reserve to U. S. M. C. R. In the case of names of officers of the Staff Corps the designations as given in article 148 shall be abbreviated as follows: Medical Corps to M. C., Supply Corps to S. C., Dental Corps to D. C., Construction Corps to C. C., Civil Engineer Corps to C. E. C., Chaplain Corps to Ch. C., Professors of Mathematics to Math.

"(22) When any article referred to in a communication is forwarded under separate cover, it shall be tagged and plainly marked in the following manner: 'From Commanding Officer, U. S. S. ________________, accompanying letter (or endorsement) No. ______, date ____________.' If possible this shall appear also on the box or package carrying the enclosure.

"(23) Stamps showing the date of receipt of papers shall be so placed as not to occupy any writing space. If stamps constituting pro forma endorsements, such as 'Received and forwarded', 'Referred for action', etc., are used, they will be placed on the face of pages as though written in a more formal manner, and will be numbered as indicated in example.

"(24) Endorsements, whether written or stamped, except those referred to in the next paragraph, shall be placed in regular order, beginning on the last page of the letter, immediately below the signature, if there be room there; if not, additional full sized sheets shall be appended to the letter to accommodate them. Endorsement slips shall not be used, except on correspondence with other departments using such slips.

"(25) All endorsements affecting pay, mileage, transportation, and traveling expenses shall be placed on the face of the original order involving travel, if practicable, otherwise on the back of the order. Such endorsements shall never be placed on sheets which might be detached from the original order.

"(26) Only one page of the sheet shall be written upon, and a margin of ¾ inch shall be left on each side and at the bottom of the sheet.

"(27) The following are examples of the forms of correspondence prescribed in this article:

Example A

No. 122–3. U. S. NAVY YARD, PHILADELPHIA,
30 June, 1920.

From: Commandant, Navy Yard, Philadelphia.
To: Commanding Officer, U. S. S. *Southwark.*
Via: (1) Construction Officer.
(2) Engineer Officer.
Subject: U. S. S. *Southwark*—Repairs to boat crane.
References:
(a) Comdg. Off. let #576–D, of 27 April, 20.
(b) Dept. let. 2345–432, of 30 April, 20, to Bu. of C. & R.
Enclosures:
(A) (separate cover) Blueprint #1234 showing proposed arrangement of boat crane.
(B) (herewith) Copy of previous correspondence on this subject.

1. The repairs to the boat crane of the U. S. S. *Southwark* are to be undertaken by the ship's force. The yard force will give such assistance as may be necessary in this connection, and you will please be governed accordingly.

A. B. ____________________

1st endorsement

No. 324–S–OD. U. S. NAVY YARD, PHILADELPHIA,
CONSTRUCTION DEPARTMENT,
1 July, 1920.

From: Construction Officer.
To: Commanding Officer, U. S. S. *Southwark.*
Via: Engineer Officer.
Subject: U. S. S. *Southwark*—Repairs to boat crane.

1. The commanding officer has been consulted concerning the desired repairs, and the necessary material therefor under the construction department will be furnished.

Estimated cost:

Labor	$10
Material	80
Indirect	40
Total	130

C. D. ____________________

2d endorsement

No. 411–237–PW. U. S. NAVY YARD, PHILADELPHIA,
ENGINEERING DEPARTMENT,
5 July, 1920.

From: Engineer Officer.
To: Commanding Officer, U. S. S. *Southwark.*
Subject: U. S. S. *Southwark*—Repairs to boat crane.

The construction officer and commanding officer have been consulted, and the necessary material under the engineering department for the proposed repairs will be furnished.

Estimated cost:

Labor	$8
Material	60
Indirect	30
Total	98

E. F. ____________________

Example B.

1382–67–C. O.

NAVY YARD, PUGET SOUND, WASH.,
HULL DIVISION,
6 May, 1920.

From: Construction Officer.
To: Commandant.
Subject: Quick-drying paint.
References: (*a*) Bureau C. & R. letter 4048–A–306 of 14 March, 20.
(*b*) Bureau C. & R. letter 4048–A–139 of 27 July, 19.
(*c*) Bureau C. & R. letter 1808–B–912 of 12 Feb., 20.
Enclosures: #13821 & #13822.

1. I request that the Bureau of Construction and Repair furnish formula for manufacturing slate-color, quick-drying paint mentioned in the first paragraph of reference (*c*).

2. Also request information as to the proper formula for boot topping on battleships. The second paragraph of reference (*c*) states that black quick-drying paint is used for boot topping on vessels painted slate color. Reference (*b*) gives black boot topping formula for use on torpedo boats, destroyers and colliers, but states nothing about modifying previous instructions regarding boot topping for battleships, the last instructions received on that point being in reference (*c*). Attention invited to enclosure #13822 showing samples of boot topping used on ships at the yard, and that mixed according to reference (*c*).

A ________________ B ________________

1st endorsement.

12879–136–c

NAVY YARD, PUGET SOUND, WASH.,
7 May, 1920.

From: Commandant.
To: Bureau of Construction and Repair.
Subject: Quick-drying paint.
Enclosure: #13822.

1. Approved and forwarded.

E ____________ F ____________ G ____________

Example C.

(Form of letterheads and subletterheads.)

NAVY DEPARTMENT
BUREAU OF CONSTRUCTION AND REPAIR

WASHINGTON, D. C., *1 July, 1912.*

U. S. S. CONNECTICUT

HAMPTON ROADS, VA., *1 July, 1912.*

UNITED STATES ATLANTIC FLEET
U. S. S. CONNECTICUT, FLAGSHIP

NAVY YARD, NEW YORK, *1 July, 1912.*

U. S. S. CONNECTICUT
(Passage, New York to Hampton Roads)

1 July, 1912.

NAVY YARD, NEW YORK
CAPTAIN OF THE YARD'S OFFICE

1 July, 1912.

NAVY YARD, BOSTON
HULL DIVISION

1 July, 1912.

NAVY YARD, NORFOLK
MACHINERY DIVISION

1 January, 1913."

The sheets of a letter or report shall be arranged in regular order from bottom to top; i. e., the first sheet on the bottom, the last sheet on top. Enclosures, if any, shall be attached in regular order on bottom of the letter, all securely fastened together, the head of the fastener underneath and the ends turned over the face of the correspondence in order that the last sheet may be readily removed to place endorsements thereon. Additional sheets bearing endorsements shall be attached, each on top of the preceding one, on the face of the correspondence, so that the last endorsement shall be uppermost. Whenever an endorsement begins on a new sheet the subject shall be repeated. Each page of letters and endorsements shall be numbered in the middle of the page about one-half inch from the bottom. These numbers shall run consecutively throughout the correspondence.

When folding is necessary, letter paper shall be folded in three and typewriter cap in four equal folds parallel to the writing.

All papers of whatever nature which by law or regulation must be signed, approved, or forwarded by an officer commanding a fleet, squadron, division, or station, the commandant of a naval station, the senior officer present, or the commanding officer of a ship, actually must be signed by such officer in his own handwriting. In his absence they shall be signed by the line officer next in rank and actually in command at the time, and the word "Acting" shall be written or stamped after his signature, but the title of the official from whom the communication emanated, as indicated after the word "From" at the beginning of the paper, shall not be modified. The name of the officer signing also shall be typewritten or stamped. Thus, in the absence of the Chief of the Bureau of Navigation, the words "Bureau of Navigation" still would appear in the letterhead, and the acting chief of bureau would write "Acting" after his signature. "Acting" shall not be used by officers left in command of ships or divisions.

When the officers in charge of sections of a bureau or office are authorized to sign mail of their section, they write or stamp the words "By direction" after

their signature, and the title of the bureau or office shall appear in the prescribed place at the head of the communication.

Communications generally are addressed to those who by regulation or law have cognizance of the subject presented or are authorized to take action thereon.

Official communications intended for officers holding positions with recognized titles are addressed to them by title and not by name, as "The Secretary of the Navy," "Bureau of Navigation," "The Commandant," "The Commander in Chief,________________Fleet (or Squadron)," 'The Commander,______________ Squadron (or Division)," "The Commanding Officer."

Officers left in temporary command of a station, fleet, squadron, or division, or in general, of any command, are addressed as if they were the regular commanding officer, on the principle that it is the office and not the person that is addressed. The temporary incumbent transacts the business so that the necessary copies and records shall be preserved in the files of the absent superior officer's office, using stationery of that office when practicable.

For the purpose of expediting public business between offices of the department or within any command, mail shall be regarded as consisting of three classes—urgent, important, and ordinary. "Urgent" mail shall be given precedence over all other, and in order that it may be readily distinguished, it shall have affixed to it a red slip, 2 by 3 inches in size, with "Urgent" printed thereon. "Important" mail shall be given precedence after urgent mail and shall bear a blue slip with the word "Important" thereon. In general, "ordinary" mail shall be handled in the order in which received.

Official mail received on board ship, or at any station, shall be opened at once by the officer actually in command for the time being, or his designated representative, and all papers requiring prompt action given immediate attention.

Official communications for the Navy Department or any of its bureaus or offices are addressed directly to the bureau or office which has cognizance over the subject matter.

It is prohibited to address communications to "The Navy Department" or to "The Navy Department (________________)."

The following are examples of authorized addresses:

The Secretary of the Navy.
The Assistant Secretary of the Navy.
The Chief of Naval Operations.
The President of the General Board.
The Chief of the Bureau of ________________.
The Major General Commandant, Marine Corps.
The Judge Advocate General.
The Chief Clerk of the Department.

When papers are addressed erroneously and reach any bureau or office under the jurisdiction of the Navy Department they are turned over to the bureau or office to which they should have been properly addressed without action thereon.

No written communication is official which has not been forwarded through the prescribed channels and with the endorsements of the officers through whom it should have been forwarded.

All officers are required to file and preserve all official documents received and copies of all official letters and endorsements sent.

Suitable files containing copies of all orders given and official letters written and the original of all letters received on public service in all offices on board

naval vessels and at shore stations shall be kept and preserved. Commanding officers may take copies of orders or letters sent and received. The system of filing shall be such as to safeguard all official papers and to render them readily accessible to reference. A flat filing system shall be used when practicable.

United States Navy filing system.

A uniform system of filing all correspondence by subjects with key letters and numbers was adopted by the Navy in 1923. This system, the rules for which are contained in the United States Navy Filing Manual, must be strictly adhered to.

The subject titles are so arranged as to be as nearly as possible self-indexing. To this end the activities of the Navy have been divided into seven main parts and each part designated by a letter. These are:

(1) A Administration.
(2) F Aircraft material.
(3) H Hydrography, meteorology, navigation, and astronomy.
(4) L Logistics.
(5) N Shore establishment material.
(6) P Personnel.
(7) S Material of ships.

The activities under each of these main parts have been so arranged that those of correlative nature or having the same general purpose are grouped together and each group assigned a descriptive file arrangement title with its corresponding file number. For example, the personnel groups run thus:

P1 Genealogy and identification.
P2 Preventive medicine.
P3 Medicine.
P4 Surgery.
P5 Dentistry.
P6 Death and casualties.
P7 Domestic relations.
P8 Social relations.
P9 Political relations.
P10 Amusement and recreation.
P11 Education.
P12 Religion.
P13 Misconduct and discipline.
P14 Appointment.
P15 Commendations, citations, and medals.
P16 Assignment and detail.
P17 Rank, precedence, and promotion.
P18 Attendance and absence.
P19 Separation (personnel).
P20 Performance.
P21 Morale.

In selecting a file number from the index, it should represent a specific title. Example: An endorsement is to be placed on an officer's request for leave from the Naval Hospital, Washington, D. C. By referring to the index it is found that the file number for that hospital is NH6, the subject of the endorsement is leave of absence. Again referring to the index it is found

that P18–1 covers that subject. If correspondence for personnel is filed in individual jackets for those concerned, then the letter J is also added. All letters and figures are now joined, but each block is separated by a slant (/). Thus the complete file number is NH6/P18–1/J and two carbon copies should be prepared, one for file under P18–1 and one for the jacket J.

A copy of the filing manual is to be found in each office.

Organization of clerical force.

The clerical work required of the medical department of a ship or hospital is carried on largely by members of the Hospital Corps. When hospital corpsmen are on independent duty the preparation and forwarding of the various reports and returns required is entirely in their care, and unless they have prepared themselves for this work it is very confusing to the bureau and entails unnecessary work in the attempt to gather accurate data from incorrect and carelessly made reports.

The duties in a naval hospital comprise all that relates to the replenishment of supplies, the upkeep, expenditure, and survey of property, the commissary department and the correspondence and clerical work of the record section incident to the above, as well as the filing of all permanent records.

Clerical activities at a naval hospital are usually divided into four sections, i. e., personnel or record office, accounting office, property office, and commissary department.

Aboard ship the clerical work comprises all the work required at naval hospitals, except commissary, and is not divided. A chief pharmacist's mate is usually in charge, the whole being under the supervision of the medical officer.

BLANK FORMS AND RETURNS OF THE MEDICAL DEPARTMENT OF THE NAVY OTHER THAN REQUISITION AND VOUCHER FORMS

To secure uniformity and accuracy of the reports and returns connected with the duties of the medical department of the Navy certain blank forms for specific purposes have been provided. To designate these forms they are lettered or numbered, and they usually bear other letters indicating that they belong to the Bureau of Medicine and Surgery.

The data contained in these reports are the basis for all of the bureau's statistical compilations, and become permanent and highly important records of the Navy Department. The Bureau of Medicine and Surgery is compelled to rely upon them for the medical histories of the officers and enlisted men of the Navy when requested to furnish specific information of importance demanded by other departmental bureaus and of vital concern to the individual. It is therefore obvious that these reports must be without error. In combining and tabulating these reports an error in any one makes the whole faulty and impairs any deductions made from such statistics.

To assure the uniformity and accuracy desired and to aid those who prepare these forms, detailed instructions for preparing each particular form are printed on the form itself, or the information desired is fully indicated in the printing and wording of the form. A great difficulty with printed instructions of this character is that those for whose guidance they are intended do not read them and consequently do not comply strictly with the directions given. Only by strict compliance with instructions can mistakes and needless correspondence be avoided. Before attempting to prepare any bureau form or report it is therefore essential to read carefully the instructions pertaining to the form and to understand their meaning.

These forms, as well as the instructions for preparing them, are subject to change, and therefore the form itself should always be resorted to for the necessary directions as to its preparation.

In transacting the business of the Medical Department of the Navy many reports and returns other than those pertaining to that department must be prepared as occasion requires. General and detailed instructions concerning their preparation are contained in bureau manuals and circular letters, or on the forms, and in all cases should be strictly followed.

Hospital corpsmen whose examinations for advancement in rating include the subject of Administration and General Clerical Procedures must familiarize themselves not only with the contents of all sections in this section but with those parts of bureau manuals, Navy Regulations, Naval Courts and Boards that pertain to the subject.

REFERENCES

Handy Book for the Hospital Corps, 1917.
U. S. Navy Regulations.
Manual of the Medical Department.
Bureau of Navigation Manual.
Hospital Corps Handbook, U. S. Navy, 1923.
Handbook of the Hospital Corps, U. S. Navy, 1930.

Section 2.—HOSPITAL SUPPLIES AND PROPERTY ACCOUNTABILITY

The title of this secton, usually spoken of by the term Property and Accounting, as employed by the Medical Department of the Navy, comprehends the procurement, custody, and final disposition of property under its cognizance, and the accounting procedures concerned therewith. It is essential, therefore, that all personnel of the Medical Department, particularly hospital corpsmen, understand the subject and be familiar with the terms in common usage and the routine procedures. In this section the terms and procedures will be covered generally by definitions, explanations, and illustrations. A study of the Manual of the Medical Department, U. S. Navy, and other official publications, for details and directives, is recommended to all personnel, especially to those whose duties are in any way concerned therewith.

In general, medical-department property is of two classes—*equipment* and *supplies*. At naval hospitals "land and buildings" constitutes a third class. **Equipment** is property that is not consumable, i. e., not easily breakable (as hospital furniture) or not readily rendered unfit for service by continued use (as surgical instruments). Consumable materials and personal services are classified as **supplies.** In order to determine if an item is equipment or supplies reference should be made to the Supply Table and Supplementary Supply Table. Items not specifically listed therein should be classified according to the classification of similar or identical items in the supply tables, and should be grouped by classes in the equipment or supplies ledger according to the listing of similar or identical items in the Federal Standard Stock Catalog.

Property accountability and accounting procedures.

Article 1194, U. S. Navy Regulations, holds the medical officer in command of each hospital, and the medical officer of each station and ship responsible and accountable for all public property under his control belonging to the Medical Department of the Navy.

In order to avoid unnecessary expenditures of public money or stores and to attend to the care and preservation of Government property, an accurate account of property under the cognizance of the Medical Department must be kept. This is accomplished by the utilization of certain accounting records, bookkeeping procedures, reports, and returns.

The following paragraph, quoted from the Code of Laws of the United States, Title 5, section 430, fixes the responsibility of the Bureau of Medicine and Surgery for its books of records and accounts:

> "The several bureaus shall retain the charge and custody of the books of records and accounts pertaining to their respective duties, and all of the duties of the bureaus shall be performed under the authority of the Secretary of the Navy, and their orders shall be considered as emanating from him, and shall have full force and effect as such."

It is impracticable for the Bureau of Medicine and Surgery to attend to all the details of accounting for monies and materials for each individual station and ship. Therefore there have been established accounting systems for use by naval hospitals and by ships and stations. Reports and returns forwarded by medical-department activities at regular intervals provide the bureau with the information necessary to carry out its financial responsibilities and control its financial obligations.

At each naval hospital there is established a Property and Accounting Office in which correspondence, records, reports, returns and documents required in the handling of the financial affairs of the hospital are prepared and maintained. This department is usually under the charge of a chief pharmacist or pharmacist designated as the Accounting Officer with an assistant designated as the Property Officer, although the duties of both these officers may be combined.

In addition to such other duties as may be assigned them the duties of officers assigned to the Property and Accounting department of a naval hospital are as listed immediately hereafter.

The accounting officer—

1. Is the assistant to the commanding and executive officers in financial and property matters;
2. Is responsible for the accounting records and keeps the commanding officer informed relative to the status of allotments, expenditures, etc. Keeps the Land and Buildings, Equipment, and Supplies Ledgers and is responsible for their accuracy;
3. Supervises the preparation of requisitions, public vouchers, payrolls, invoices, requests for allotments, surveys, annual estimates and advanced years' estimates of expenditures, and all other forms and reports pertaining to financial matters;
4. Submits to the commanding officer, via the executive officer at the end of each month, a report on the condition of allotments, and a statement of the balances available, or prospective over-obligations, if any, with reasons therefor; and
5. Keeps himself informed of the laws, regulations, and instructions governing the preparation and submission of accounting records and reports and keeps the books of account and financial records of the hospital.

The property officer—

1. Is custodian of all stores and equipment belonging to the hospital, exercising personal and careful supervision over them and the

economical use and expenditure thereof, reporting any deficiencies to the accounting officer;

2. Receipts for, issues, and accounts for all stores (except commissary stores) and equipment;
3. Maintains the proper records of equipment issued to the several services and facilities of the hospital, obtains and retains in file custody receipts therefor, and reports any deficiency in property charged to these activities to the accounting officer;
4. Takes an actual inventory of stores (except commissary stores) on hand at the end of each quarter and reports to the accounting officer any differences in the amounts as shown on the books and as determined by actual inventory;
5. Correlates the inventories from the various activities as of 30 June, each year, and prepares the annual inventory for submission to the bureau;
6. Is responsible for the management and accounting of the pharmacy unless the commanding officer shall specifically except this responsibility from his assigned duties; and
7. When detached or relieved, makes a complete inventory of all equipment and supplies (except commissary stores) and transfers them to his successor.

The accounting system prescribed for naval hospitals is based upon double-entry bookkeeping principles modified to provide data essential to central control and internal management. Such elements of appropriational, cost, and fiduciary accounting as will provide the necessary data are utilized in this system which is designed to suit the needs of all naval hospitals regardless of size or of the number of administrative units into which each hospital may be divided. A knowledge of the fundamental principles of double-entry bookkeeping procedure is necessary to the proper understanding of the accounting system in use at naval hospitals. As a detailed discussion of the fundamentals of bookkeeping is beyond the scope of this section, and in view of the fact that accounting instructions are contained in Chapter 20 and Circular Letter F, Appendix D, Manual of the Medical Department, U. S. Navy, only brief mention of medical department accounting records and reports will be made here.

Naval hospitals.—The accounting records required to be kept at each naval hospital are:

1. *Journal.*—The Journal is a book of original entry in which is recorded, either in detail or in summary form, the debit and credit effects of financial transactions.

2. *Charge Register.*—The charge register is a columnar subsidiary journal record in which is recorded the debit and credit effects of financial transactions involving the receipt of property, except property received by transfer voucher or taken up from inventory adjustment vouchers.

3. *General Ledger.*—The general ledger is the control or master ledger in which is recorded the debit and credit effect of every receipt and expenditure of property. Postings to this ledger are made only from the Journal.

4. *Land and Buildings Ledger.*—The land and buildings ledger is an itemized record of the receipt and expenditure of land and buildings items.

5. *Equipment Ledger.*—The equipment ledger is an itemized record of the receipt and expenditure of all equipment items.

6. *Supplies Ledger.*—The supplies ledger is an itemized record of the receipt and expenditure of all consumable supplies except provisions.

7. *Commissary Ledger.*—The commissary ledger is an itemized record of the accounts of the commissary department, both as to quantity and cash value of provisions.

8. *Expense Analysis Register.*—The expense analysis register is a cost analysis of the hospital operating expense subdivided to show: (*a*) The operating cost by departments; (*b*) the expenditures on account of pay of the military staff; and (*c*) the expenditures made for the Navy as a whole.

9. *Recapitulation of Ledger Accounts.* (*Register No. 3*).—The recapitulation of ledger accounts is prepared quarterly and when decommissioned, in duplicate, and is forwarded to the bureau not later than 15 days after the close of each quarter. In addition to the recapitulation of general ledger accounts this form furnishes a recapitulation of each Expense Analysis Register account and information related to both recapitulations. When forwarded it is accompanied by other required financial reports and supporting data. The duplicate copy is retained in the files of the accounting office of the activity submitting the report.

10. *Quarterly Ration Return.* (*N. M. S. H. Form 36*).—The quarterly ration return is prepared in duplicate, quarterly and when decommissioned, and the original is forwarded to the bureau with the Recapitulation of Ledger Accounts (Register No. 3). This report supplies the bureau with information as to subsistence furnished personnel, the amount of reimbursement received or to be obtained by the bureau therefor, the value of provisions received and expended, and the average daily cost of ration.

Ships and stations.—The accounting system for shore stations other than naval hospitals and for ships consists principally of records of the receipts and expenditures of materials and services and of records of appropriational expenditures and obligations. The following financial records are required to be kept in the operation of this system:

1. *Journal of Receipts and Expenditures of Medical Department Property.*—This journal is the book of original entry for stations and ships and is used to record data relative to each financial transaction involving the receipt and disposition of medical-department property. It should be posted daily, or as frequently as may be necessary to keep the record up to date. Each entry should be substantiated by a duly authenticated voucher (N. M. S. Form 4 invoices, stub requisition summaries and stub requisitions, public vouchers, transfer vouchers, surveys, issue vouchers, etc.) and the vouchers should be preserved in such manner as to be readily accessible for reference or audit purposes. At the close of each quarter and upon decommissioning, each amount column in the Journal should be totaled and the sums entered on the Statement of Receipts and Expenditures of Medical Department Property (N. M. S. Form E).

2. *Equipment Ledger.*—In this ledger a sheet (N. M. S. Form W) is kept for each item or group of identical items of equipment arranged by Supply-Table classes, Supplementary Supply-Table classes, and Federal Standard Stock Catalog classes. A control sheet for each class and a master control sheet for all classes should be kept. Receipts of equipment are posted in this ledger from the data contained in the substantiating voucher following posting of the total amount of the voucher in the Journal of Receipts and Expenditures of Medical Department Property. Expenditures of equipment are posted to this ledger from approved surveys and transfer vouchers, following posting in the Journal.

3. *Supplies Ledger.*—In this ledger a sheet (N. M. S. Form W) is kept for each item or group of identical items of supplies arranged by Supply-Table

classes, Supplementary Supply-Table classes, and Federal Standard Stock Catalog classes. A control sheet for each class and a master control sheet for all classes should be kept. Receipts of supplies are posted in the same manner as are receipts of equipment. Expenditures are posted from issue vouchers (N. M. S. Form R.), transfer vouchers issued, and inventory adjustment vouchers, in the same manner as expenditures of equipment are recorded. New unit costs of items are determined and recorded on the ledger sheets upon receipt of additional items having a unit cost greater or less than the unit cost then appearing on the ledger sheets.

Accounting records and reports used by the Medical Department provide statistics of two kinds: *Appropriational*, and *cost*. By **appropriational accounting** is meant the procedures involved in recording and analyzing the value of receipts of materials and services obtained by reason of the expenditure or transfer of funds from appropriations under the cognizance of the Bureau of Medicine and Surgery or from the Naval Hospital Fund. **Cost accounting** concerns the procedures involved in recording and analyzing the value of materials and services consumed in the operation of an activity regardless of the source from which such materials and services may have been received.

N. M. S. Form B is the report of allotment expenditures and obligations used in appropriational accounting and is forwarded to the bureau quarterly by all medical-department activities required to submit financial returns. This form is designed to report expenditures as follows: By appropriation, and by objects of expenditure and subheads under objects, including totals expended for supplies, for equipment, and, at naval hospitals, naval medical supply depots, and the naval medical school, on land and buildings. It furnishes information concerning the allotment status as to amount available at the beginning of the period covered by the report, amount expended during the period covered by report, and obligations outstanding and unexpended balance at end of the period. It also analyzes the expenditures reported to show the source (stub requisition, purchase requisition, bureau work request, etc.) of materials, subdivided according to the appropriations chargeable.

On the face of the form are reported the expenditures under the supply depot credit allotment, the status of that allotment, the data concerning each medical supply depot requisition received during the accounting period covered by the report, and the data with respect to each such requisition outstanding at the close of the accounting period. On the reverse of this form is reported an analysis of the receipts from medical supply depots by supply table classes and subheads, subdivided into supplies, equipment, and mortuary supplies and equipment. This analysis is prepared by consolidating the cost data shown on the reverse of all naval medical supply depot requisitions and invoices (N. M. S. Form 4) actually receipted by the activity during the accounting period covered by the report. (*See* sample forms on pages 798 to 893, inclusive).

It is essential that accurate information be furnished on Form B as it is used in the bureau for many purposes, chiefly to furnish the information required for allotment control and analyses of expenditures by subheads.

N. M. S. Form E is the statement of receipts and expenditures of medical-department property and is forwarded to the bureau by such ships and stations as are required to submit medical-department financial returns. It is designed to furnish a perpetual inventory control and cost analysis, and reports the receipt and expenditure of all materials and services, regardless of source, divided into equipment and supplies, and analyzes certain receipts and expenditures. Incidental information as to operating expense, complement, and medical

services rendered civilians is supplied on lines 46 to 55 inclusive. (*See* sample form on pages 796 and 797). The information contained on all N. M. S. Forms E submitted is consolidated in the bureau. In order to coordinate the various expenditures and consider the entire problem of financing the Medical Department, it is essential that this report correctly reflect the financial affairs of the reporting activity.

The initial financial record is the **allotment card** covering the allocation of funds to medical-department activities. Allotment cards, on each of which is shown the name of the appropriation, the allotment number, and the amount of money allotted, are forwarded by the bureau to shore stations with the returned annual estimate of expenditures, as approved. Allotment cards for ships are prepared and forwarded by the bureau. Except for supply-depot credit allotments, the total amount allotted is divided into quarterly apportionments, the amount apportioned for each quarter depending upon the estimated requirements of the activity during each quarter.

Allotments are classified by the Bureau of Medicine and Surgery as *appropriational* (*money credits*) and *medical supply depot* (*material credits*).

Appropriational allotments are money credits made to medical-department activities from the Congressional appropriations Medical Department, Navy, and Care of the Dead, Navy, and from the Naval Hospital Fund, and represent the amounts reserved or set aside by the bureau exclusively for the activities to cover the anticipated expenditures and transfers of funds in the procurement of the materials and services necessary to carry out the mission of the Medical Department.

Medical supply depot allotments are material credits authorizing withdrawals of equipment and supplies from stock at naval medical supply depots and are measured in terms of money for convenience. In such withdrawals no disbursement or transfer of funds is involved because the materials were paid for from funds allotted to the medical supply depots for that purpose. The stock available for issue at medical supply depots is procured from funds allotted by the bureau to the depots annually, prior to 1 July, to cover regularly stocked Supply-Table and Supplementary Supply-Table items estimated to be required by all medical-department activities for one year.

Upon receipt of the allotment cards, the medical department of an activity is prepared to initiate the procedures necessary to obtain the needed materials and services for its proper function.

Procurement.

The financial duties of the Bureau of Medicine and Surgery are set forth in Sections I and II, Chapter 20, Manual of the Medical Department, U. S. Navy.

Not all monies under the cognizance of the Navy Department are appropriated funds; there are also Working Funds and Trust Funds. A notable example of a trust fund, and one of interest to hospital corpsmen, is the Naval Hospital Fund which derives its revenue from within the naval service and is administered by the Secretary of the Navy, the Trustee. The sources of revenue of this trust fund are:

1. By the deduction of 20 cents per month from the pay of each officer, seaman, and marine (Sec. 4808, R. S.).
2. By fines imposed on officers, seamen and marines (Sec. 4808, R. S.).
3. By the value of one ration per day allowed for each officer, seaman, and marine, during his continuance in hospital (Sec. 4812, R. S.).

4. By the relinquishment of disability pensions due officers, seamen, and marines (other than Veterans' Administration beneficiaries) while inmates of naval hospitals (Sec. 4813, R. S.).

5. By forfeitures on account of desertion (Act of June 7, 1900, 31 Stat. 697).

Monies required for the maintenance and operation of medical-department activities are made available from two sources: Annual appropriations and a trust fund. Services and materials are procured for the medical department of ships and stations and at hospitals both from the money appropriated and from the Naval Hospital Fund, the trust fund just mentioned.

Annual appropriations are made by the Congress for expenditure during a specified fiscal year. The annual appropriations included in the Appropriation Act for the Naval Establishment which pertain to the Bureau of Medicine and Surgery are titled as follows:

(*a*) Medical Department, Navy;
(*b*) Care of the Dead, Navy; and
(*c*) Salaries, Bureau of Medicine and Surgery.

The detailed purpose of expenditure under the fixed title of appropriations is contained in each annual appropriation act. The language of the appropriation controls expenditures to be made under that appropriation. For example, the annual appropriation, Care of the Dead, Navy, by its title presupposes, and correctly so, that expenditures for the care of the remains of the dead are payable from this appropriation. The language of this appropriation reveals the specific objects such as funeral expenses, recovery of bodies, cremation, preparation for burial, transportation, burial expenses of pensioners and destitute patients, and so forth. The language of an appropriation or fund must be studied carefully to determine the one to which an expenditure is chargeable.

It should be remembered therefore that the appropriations and funds are not interchangeable and do not constitute a lump sum to be expended as desired. Rather, the language of the act, naming a specific purpose or object, prevents the use of funds from a less specific appropriation for that particular purpose or object.

The Naval Appropriation Act for each fiscal year contains the wording of the annual appropriations; Chapter 20, Manual of the Medical Department, U. S. Navy, defines expenditures to be made from the Naval Hospital Fund.

Funds to operate a naval hospital or the medical department of a naval station are obtained by the medium of an annual estimate of expenditures. As ships have approximately the same expenses from year to year the bureau does not require individual ships to submit an annual estimate, but allots funds, by classes of ships, on an average expenditure basis.

Under ordinary circumstances, a medical-department activity should not incur any appropriational obligations unless, and until, an allotment for the purpose has been granted by the bureau. Certain contingencies indicated in Article 1396, U. S. Navy Regulations, permit the commanding officer to authorize appropriational expenditures without an allotment. In each such case, however, a full report of the emergency must be made to the bureau in order that provisions may be made to meet the expenditure.

The **annual estimate of expenditures** may be defined as a detailed analysis and itemization of the appropriational expenditures which, it is expected, will be required to provide the submitting activity with the materials and services necessary for its maintenance and operation for a stated period. As the manner

of submitting estimates and the data required to be submitted to the bureau with each estimate is subject to change, the current circular letter on the subject should be consulted before preparation.

An annual estimate is submitted to the bureau by shore stations to cover the period of one fiscal year from 1 July of one to 30 June of the next calendar year. Another estimate, known as "Tentative Estimate, Advance Fiscal Years" is also submitted annually. For example, an annual estimate would be submitted for the period: 1 July, 1942, to 30 June, 1943. The tentative estimate for advance fiscal years is submitted for the two fiscal periods immediately following the period covered by the annual estimate, in this case for the period 1 July, 1943 to 30 June, 1944, and for the period 1 July, 1944 to 30 June, 1945.

Annual estimates are reviewed in the bureau and when approved constitute a fiscal guide for the activity.

The preparation of an annual estimate is not a one-man job. The full cooperation of all persons having to do with materials and services is essential to a complete and intelligent estimate covering requirements for all departments. The data required for the preparation of estimates should be collected from official weekly inspections, notes, experience data, and so forth, classified and filed for reference.

Materials and services may be obtained on the following official request forms, duly prepared and accomplished:

1. Purchase Requisitions (S. & A. Form 76 and 76a ashore, and S. & A. Form 44 and 44a afloat);
2. Stub Requisition (Local memorandum invoices);
3. Requisition for Labor (N. Y. O. Form 6);
4. Bureau Work Request (Special M. & S. Form);
5. Medical Supply Depot Requisition and Invoice (N. M. S. Form 4); and
6. Transfer Vouchers (Usually S. & A. Form 71).

In order that a supply officer may make a payment legally, he must have definite authority therefor. The approval of a purchase requisition by the cognizant bureau, or bureaus, constitutes the necessary authority to make payments. A purchase requisition, therefore, may be defined as an authorization to the supply officer designated thereon to make a contract in accordance with the terms of the requisition.

Regarding the expenditure of funds of the Medical Department of the Navy it should always be borne in mind that *officers of the Supply Corps and Marine Corps Quartermasters are the only persons in the naval service who may make appropriational expenditures, an exception sometimes being made when the Chief of the Bureau of Supplies and Accounts specifically designates an officer as Special Disbursing Agent.*

It naturally follows, therefore, that the appropriational expenditures reported by medical department activities must agree with the appropriational expenditures reported by the supply officer.

Procurement by requisition, in contrast to procurement by transfer, presupposes prior approval of a requisition and an allotment of sufficient funds to cover the cost. An allotment of funds may be defined as evidence of a credit which has been established for the maintenance, operation, improvement, or extension of a specified medical-department activity. The sum allotted is based upon general and specific projects of an approved fiscal plan. Contrary to general opinion, if sums allotted are in excess of needs for approved projects, due to over-estimates, deferred projects, or otherwise, the excess is not available

for accomplishment of unapproved projects, without specific approval for such use. It should be borne in mind that a project is approved prior to the allotment of funds.

Certain minor procurements of materials and services are required frequently by medical-department activities. It would be impracticable for an activity to submit a purchase requisition to the bureau for approval in each such case, prior to obtaining the necessary materials or services. This situation is met by the submission and subsequent approval of annual purchase requisitions covering such recurring needs throughout the fiscal year. The language of such requisitions is approximately as follows:

For hospitals and large stations

> For sundry items of supplies, equipment and services, *including services of blood donors,* in such quantities and at such times as may be required during the fiscal year 19—.
>
> (The services of blood donors are omitted from requisitions drawn under the Naval Hospital Fund because such services are provided for in and are chargeable to the appropriation Medical Department).

For ships and small stations

> For sundry items of medical and dental supplies; special diets for the sick; laundry supplies and services; services of blood donors; repair of and parts for medical-department equipment; repair of and parts for motor vehicles; in such quantities and at such times as may be required during the fiscal year 19—.
>
> (Requests for dental supplies and repair of and parts for motor vehicles are omitted from requisitions submitted by ships and stations having no dental officer and at which there are no medical-department motor vehicles).

As may be seen, the approval of an annual purchase requisition authorizes a supply officer to make contracts for the purchase of a variety of items, according to the language appearing on the requisition.

The proposed method of procurement of each item on the approved annual estimate of expenditures must be given, that is, whether by Special Purchase Requisition (SR), Annual Purchase Requisition (AR), Stub Requisition (S), or Bureau Work Request (BWR). The method by which an item will be procured is determined by the source from which it is to be obtained as follows:

(*a*) Obtain on N. M. S. Form 4 requisition, if the item is listed on the Medical Department Supply Table or Supplementary Supply Table.
(*b*) Obtain on stub requisition, if the item is listed in the Federal Standard Stock Catalog as Navy material.
(*c*) Obtain on Bureau Work Request, if work involved in connection with the item is beyond the capacity of the hospital force employed.
(*d*) Obtain on purchase requisition, if the item must be procured in the open market where a cash payment is involved.

In determining the method of procurement of an item the sources of supply are to be considered in the following order of priority:

1. Naval Medical Supply Depot;
2. Supply Officers' stores;
3. Bureau Work Request, to be performed by yard labor or Public Works contract; and
4. Purchase requisition.

The three naval medical supply depots are located in Brooklyn, N. Y.; Navy Yard, Mare Island, Calif.; and Canacao, P. I. Supply-Table and Supplementary Supply-Table stores are purchased in large quantities by the procuring depot at Brooklyn, and stored locally, or in the naval medical supply depots at Mare Island and Canacao. Issues from these depots are usually made under the authority of an N. M. S. Form 4 requisition, approved by the bureau. The items listed on the requisition are boxed by the depot and shipped to the medical officer requesting them through the facilities of the Supply Department.

The bureau provides tables listing items stocked, for issue, at naval medical supply depots. The tables are known as the Supply Table of the Medical Department, U. S. Navy, and the Supplementary Supply Table of the Medical Department, U. S. Navy. Instructions as to ordering, and limitations on particular items, are contained in each table.

Items carried in stock by the local supply officer may be withdrawn on stub requisition for use provided funds are available in the appropriate allotment of the medical-department activity. The form of stub requisition to be used may differ at various activities.

When labor (including incidental materials) is required for maintenance of buildings, ambulances, or other items of equipment, and such labor is beyond the capacity of the force employed, an M. & S. "Bureau Work Request" form is submitted covering the project.

Custody.

From the date of procurement (receipt) of medical-department property until the date of its disposition an individual member of the medical department is responsible, in a fiduciary capacity, for its custody.

The custody of medical-department property includes the accountability, inspection, and storage of such property and Article 1132, U. S. Navy Regulations delegates to the medical officer of each ship the charge of all material and stores on board which are under the cognizance of the Bureau of Medicine and Surgery. Medical officers in command of naval hospitals and the medical officers at shore stations are likewise held responsible for medical-department property in their charge by Article 1194, U. S. Navy Regulations. Persons charged with the custody of medical-department property are not relieved of responsibility therefor until custodianship is regularly transferred to a successor in accordance with existing instructions, or is disposed of by survey.

Also, by U. S. Navy Regulations, officers are required to avoid any unnecessary expenditure of public money or stores, and so far as may be in their power prevent the same in others, and to attend to the care and preservation of all Government property in their charge.

Hospital corpsmen who are custodians of or whose duties are concerned with the care of medical-department property are expected to do everything in their power to preserve such property and prevent its loss, waste, or unauthorized use. They also are expected to be thoroughly familiar with the instructions governing the custody of and accountability for medical-department property as contained in the U. S. Navy Regulations and the Manual of the Medical Department, U. S. Navy.

As the details of the inspection and storage of medical-department property vary with the location of activities they will not be discussed in this section.

Disposition.

Equipment and supplies consumed in any given period result in a depletion of material inventories and a change in the total value of stock on hand;

therefore, records are needed to reflect the physical and financial changes and to provide an administrative control. The primary form used to record storeroom issues at medical-department activities is N. M. S. Form R. Some materials and services are issued without passing through the storeroom, such as payment of salaries and wages to civil employees; bulky stores such as coal or fuel oil; special medicines in small amounts procured locally and consumed immediately upon receipt; etc. Nevertheless an issue voucher, or other document, covering such supplies is essential: 1. To record the issue authorization; 2. To relieve the storekeeper of responsibility; and 3. To substantiate the necessary entries in the accounting records.

After materials are issued from the storeroom of a medical-department activity the issue vouchers are completed by entering the unit and extension prices on them and the total quantity and cost of each item is then recorded as an expenditure on the respective ledger sheets of the appropriate ledger. Records of quantity and cost of materials withdrawn are tabulated from these vouchers and entered on ledger sheets. A recapitulation of such issues is recorded in the Journal of Receipts and Expenditures of Medical-Department Property at stations and on ships, and in the Expense Analysis Register at hospitals. These recapitulations form the basis for the expenditure entries made on N. M. S. Form E and in the Statement of Expense Analysis Register Accounts on the reverse of N. M. S. Register No. 3, respectively.

Equipment and supplies under medical-department cognizance may be transferred to another naval activity or to another Federal activity in emergencies or as a matter of expediency. Such a transfer constitutes an expenditure "by transfer." The first step in the accounting procedure is the invoicing of the material on Bureau of Supplies and Accounts Form No. 71. When receipted, this form constitutes the duly authenticated voucher required to substantiate the entries in the accounting records and reports with regard to the disposition of the material transferred.

Equipment in excess of requirements, missing, worn out, or otherwise unfit for use, is required to be made the subject of a *property survey*. Surveys are requested and the reports are recorded on Bureau of Supplies and Accounts Form No. 154. U. S. Navy Regulations and Chapter 20, Manual of the Medical Department, U. S. Navy, contain complete instructions governing survey procedures. Surveys of property are of two types—*formal* and *informal*.

The fiduciary (custodial) accountability for property may be terminated by means of a properly executed property survey. The term, property, embraces both medical-department supplies and equipment. A property survey is the act of inspecting Navy materials (property) by a duly appointed officer or board of officers with a view to determining and reporting facts regarding the designated property items and making appropriate recommendation concerning the disposition of such items.

The recommended disposition of medical-department property which has been so inspected (surveyed) is subject to the approval of the Bureau of Medicine and Surgery. To this end, the surveying officer or survey board performing the acts of inspection submits a report on the prescribed form (S. & A. Form No. 154), listing in the space provided the condition, cause, responsibility, recommendation, and appraised value of each item.

A formal survey is a property survey performed by a surveying officer or survey board appointed by the senior officer present. A survey board consists of one or more naval officers, at least one of whom must be commissioned.

An informal survey is a property survey performed by the head of depart-

ment having charge of the property. No survey board or surveying officer is appointed in cases of informal survey.

To determine whether a property survey shall be formal or informal, with respect to medical-department property, the instructions published in Chapter 20, Manual of the Medical Department, U. S. Navy, should be followed.

A formal survey is required:

(*a*) When an item of equipment has a book value in excess of $25, or a group of identical items has a book value in excess of $100;
(*b*) When the head of department is not a commissioned officer; and
(*c*) When specifically directed by the commanding officer of a ship, or the commandant or commanding officer of a shore station.

An informal survey may be held when none of the foregoing restrictions apply.

The form used for reporting a property survey is S. & A. Form No. 154. An effort should be made to conserve forms and to this end, where all items cannot be listed on the form itself, the additional items may be listed on standard typewriter paper. The form is designed so that all information with respect to a particular item will be on one page. The upper half only of each sheet is to be used for listing the items to be surveyed, the lower half being reserved for use of the surveying officer in reporting the condition, cause, responsibility, recommendation, and appraised value of the items appearing in the upper part of the same sheet. When additional sheets are required and are prepared on standard typewriter paper, each sheet shall be divided into two parts in the same manner as S. & A. Form No. 154 is divided. The upper part of the additional sheets shall be used for listing the items to be surveyed and the lower part for the report on the items appearing in the upper part.

The condition, cause, responsibility, recommendation, and appraised value, required to be indicated for each item are explained as follows:

Condition refers to the actual physical condition with relation to the original purpose, that is, broken; hinges sprung; leaky; chipped; etc.

Cause refers to the reason the item is in its present condition, if such can be determined. The usual causes are: Worn out in use; excess; lost; accidentally dropped; damaged by fire; or some other happening or event which brought about the present defects.

Responsibility refers to the person or persons who caused the item to be defective. Usually no responsibility attaches to articles worn out in use or rendered defective by some unavoidable act, the usual report as to responsibility being: None; Responsibility cannot be fixed; etc.

Recommendation refers to the opinion of the board regarding the most appropriate disposition of the item. The usual recommendations are: Destroy; To naval medical supply depot (naming the depot); To supply department for sale; To yard scrap heap; or, Retain and repair on ship or station. The Manual of the Medical Department, U. S. Navy, paragraph 3076, contains detailed instructions with respect to the recommendations mentioned. The surveying officer, or survey board, is required by Article 1911, U. S. Navy Regulations to state in the recommendation for disposition whether or not replacement is required.

Appraised value is the estimated monetary value of the item in its present condition. Items recommended for transfer to a naval medical supply depot for repair or for further disposition, or to a supply officer for sale or exchange shall, in each case, be assigned a conservative appraised value.

The original and two copies of property survey reports on medical-department property are submitted to the Bureau of Medicine and Surgery for items

of equipment or supplies all of which are recommended to be destroyed. Paragraph 3076, Manual of the Medical Department, U. S. Navy, should be consulted for the correct number of copies required to be submitted in cases where the disposition recommended is other than destruction.

When the survey report is returned to the ship or station by the bureau as "approved" or "approved as modified", the recommendations appearing thereon should be carried out. The commanding officer appoints an officer to supervise the destruction of all items approved to be destroyed, and after destruction is completed the officer so appointed places an endorsement to this effect on the survey report. Items to be transferred or retained are handled by the property and accounting officer or the medical officer in accordance with the recommendation for each item as it appears in the approved survey.

The individual items surveyed are written off in the Equipment Ledger, the Supplies Ledger, or the Land and Buildings Ledger, depending on the nature of the items. At naval hospitals, the value of the material disposed of by authority of approved survey is accounted for in the hospital's financial records and is ultimately reported on N. M. S. Register No. 3. On ships and at stations the value of the material so disposed of is recorded in the Journal of Receipts and Expenditures of Medical-Department Property and is ultimately reported on the appropriate line, and in the appropriate analysis, on N. M. S. Form E.

In order to emphasize the importance of maintaining, in the proper manner, the Journal of Receipts and Expenditures of Medical Department Property on board all ships and at all stations required to submit N. M. S. Forms B and E, samples of these forms have been prepared and are reproduced at the end of this section. These sample forms are intended to demonstrate by example the manner in which the Journal should be prepared and maintained, the method of preparing financial reports, and the relation of each form to each of the others.

A detailed discussion of the entries in the sample N. M. S. Forms B and E will not be undertaken here. Instructions for the preparation and submission of these forms are covered fully in Circular Letter F, Appendix D, Manual of the Medical Department, U. S. Navy. An understanding of the purpose of each form and its relation to each of the others can be most readily obtained by tracing each entry in the sample Journal to the various lines, tables, and analyses on the sample N. M. S. Forms B and E.

The comments on medical-department accounting procedures appearing next are made in order that the reader may observe the procedures in concrete form and thus obtain a working knowledge of the proper method of recording and reporting transactions involved in the procurement and disposition of medical department property on board ships and at stations.

Allotment expenditures to liquidate obligations against allotments for a previous year are reported *monthly* on supplementary N. M. S. Form B until all obligations outstanding at the close of the previous fiscal year are liquidated. However, on board ships and at stations, the materials or services received by reason of the incurrence of such obligations are considered to be current receipts and are properly taken up in the Journal as at the date of liquidation and are reported as receipts on the N. M. S. Form E for the quarter in which the obligations are liquidated. In the sample forms this procedure applies to S. D. Requisitions Nos. 14–40, 16–40, and to Public Voucher No. 1–12 (40).

By reference to the sample forms it will be noted that bills of lading covering the transportation of remains are recorded and reported as though they were

public vouchers. This procedure is followed because charges for transportation of remains, authorized by Government bill of lading or transportation request, are ultimately liquidated by public voucher. Expenditures for transportation of remains are made by disbursing officers in the same manner as other expenditures on public vouchers. In view of the long period of time which ordinarily elapses between the incurrence of the obligation and the payment for the transportation of remains, and since a very accurate estimate may be obtained from the initial carrier, the estimated cost of transportation of remains as obtained from the initial carrier is taken up by the medical-department activity shipping the remains from a memorandum voucher prepared for that purpose. The estimated cost of transportation is recorded as a receipt by public voucher in the Journal and in the Supplies Ledger. An issue voucher (N. M. S. Form R) is prepared immediately following the preceding entry and is recorded as an expenditure in the Journal and in the Supplies Ledger. It is reported as an appropriational expenditure on N. M. S. Form B, and as both a receipt and an expenditure on N. M. S. Form E, for the accounting period in which shipment is made. Adjustment of the expenditures reported by the medical-department activity is made in the Bureau of Medicine and Surgery when the charges are finally paid. Obligations for transportation of remains in foreign countries, when liquidated locally by authority of public vouchers, are taken up in the Journal and the Supplies Ledger and are reported on N. M. S. Form B for the accounting period in which the public voucher is dated.

When materials are procured under a contract which does not include free delivery to the medical-department activity, the cost of transportation is added to the purchase price as an allotment charge and as a part of the book value of the material. Transportation charges on such items are always paid for from the Naval Supply Account Fund, a revolving (working) fund under the cognizance of the Bureau of Supplies and Accounts, but the appropriation paying for the material obtained on the contract is ultimately chargeable with the cost of transportation.

The transportation charges, when paid, are taken up in the Naval Supply Account, by a supply officer, as though they were actually material and the cost is charged to the Naval Supply Account Fund. In order to charge the cost of transportation to the appropriation paying for the material obtained on the contract, and in order that the medical-department activity for which the material was purchased may be furnished the necessary information for entry in the accounting records and financial reports, the transportation charges are transferred as "material" to the Appropriation Purchases Account and the Naval Supply Account is credited. At the time the transportation charges are transferred from the Naval Supply Account to the Appropriation Purchases Account the cost of transportation is charged to the appropriation paying for the material obtained on the contract and the Naval Supply Account Fund is credited. Up to this point all transactions and accounting procedures in connection with the transportation charges are handled by officers of the Supply Corps. The medical-department activity concerned clears the transportation charges through the Appropriation Purchases Account by furnishing the supply officer, in whose account they are lodged, with an accomplished stub requisition.

As the appropriation paying for the material obtained on the contract has also been charged with the transportation cost the stub requisition invoicing such cost is taken up by the medical-department activity concerned as a charge to its allotment under that appropriation and is recorded in the Journal in the column headed N. S. A. material. Transportation charges being a part of the gross cost of placing the material in a "ready to use" status at the activity

are therefore an integral part of the "book value" of the material and are taken up on the ledger sheet recording the description and purchase price of the material. In the sample forms this procedure applies to the transportation charges on the ambulance.

In connection with the preceding discussion of transportation charges on material purchased on contract, attention is invited to the fact that the cost is charged to the appropriation for the fiscal year in which the supply officer actually takes up the charges in his Appropriation Purchases Account and not to the appropriation current at the time the material was purchased. For example, an ambulance may be paid for from the appropriation Medical Department, Navy, 1941 while the transportation charges incurred in its delivery may be paid for from the appropriation Medical Department, Navy, 1942.

In connection with the property surveys recorded in the sample Journal it will be noted that Survey No. 1–41 is recorded as having been approved by the Bureau of Medicine and Surgery during the fiscal year 1940 and that the typewriter value to be expended in accordance therewith is recorded as having been expended on the first day of the fiscal year 1941. The fact that Survey No. 1–41 is so recorded is explained by the assumption that the survey was submitted during the month of June, 1940, accompanied by Special Purchase Requisition No. 4–41, in order to comply with instructions which require that purchase requisitions for replacement typewriters be accompanied by the survey request and report on the typewriters to be replaced and that they be forwarded to reach the Bureau of Medicine and Surgery not later than 15 July of each year. Annual contracts for the procurement of typewriters expire on 31 July of each year. Obviously, if the field activity is located at a considerable distance from the bureau the survey and requisition will, of necessity, have to be forwarded prior to the beginning of the fiscal year in which they are to become effective in order to insure compliance with instructions. Even though the approved survey had been received by the activity prior to 1 July, 1940 the typewriter value to be expended in accordance therewith will not have been expended until, or after, that date.

The fact that Survey No. 6–40 was not expended during the fiscal year 1940, although the date of approval by the Bureau of Medicine and Surgery is recorded as 3 June, 1940, may be explained by assuming that the approved survey was not received by the activity until 1 July, 1940 after the Journal for the fourth quarter of the fiscal year 1940 had been closed. The fact that it apparently was received on the same date as Survey No. 1–41, approved by the bureau 17 days later, is explained by the fact that surveys on ambulances and motor vehicles must be returned to the activity via the Bureau of Yards and Docks in each case and also via the Bureau of Supplies and Accounts when transfer to a supply officer for sale or other disposition has been recommended.

The reader should note that the value to be expended by survey is expended upon receipt of the original of the survey bearing the approval of the Bureau of Medicine and Surgery, or on the first day of the fiscal year in which series it is numbered, and that the expenditure is not held in abeyance until any items having an appraised value have been disposed of in accordance with the approved recommendation of the surveying officer or survey board.

A transfer of material is not complete until the receipted transfer voucher issued, *signed by the officer to whom the material is invoiced*, has been received by the activity issuing the transfer voucher. The accountability for the material remains vested in the activity transferring it until such time as the signed receipted transfer voucher is received from the activity which is to take up the material in its accounting records. The value of the material transferred

should be expended from the accounting records only after receipt of the transfer voucher, accomplished as stated before, regardless of the period of time intervening between the transfer of the material and receipt of the accomplished transfer voucher. Therefore the expenditure of such material should appear in the Journal and on the N. M. S. Form E for the quarter in which the properly accomplished Transfer Voucher Issued is received. The expenditure will appear in the Journal and the financial reports for the quarter in which the material is transferred only when the signed receipted transfer voucher is received in the same quarter as that in which the material was transferred. A signed receipted copy of all Transfer Vouchers Issued must accompany financial reports for the quarter in which the material so transferred is expended from the accounting records of the activity. The preceding comment is applicable to T. V. I. No. 12–40 as recorded in the sample Journal and the sample N. M. S. Form E.

It should be noted that the value of Naval Supply Account (N. S. A.) material received on stub requisitions has been taken up in the sample Journal from the monthly Summary of Stub Requisitions (S. & A. Form 178) and not from the individual stubs received at the time each issue was made by the supply-department activity from which the material was obtained. The individual stubs for each month should be filed in numerical sequence until the stub summary is received at the end of the month. The charges shown on each individual stub should be checked against the charges reported on the stub summary. In the event discrepancies are found the supply department should be contacted and the necessary adjustments made to bring the total money value of the individual stubs into agreement with the total money value reported on the stub summary. The stub summary should not be signed by the medical officer until appropriational charges have been verified. This procedure should be followed for the reason that individual stubs furnished at the time the material is issued are subject to adjustment for final appropriational charge by the accounting officer of the supply-department activity furnishing the material. After verification of the stub summary the charges shown thereon should be entered in the Journal and in the appropriate ledgers. The charges for equipment and the charges for supplies should be segregated and entered in their respective sections of the Journal and in their respective ledgers. The total money value of the summary, as verified, is reported on N. M. S. Form B as an allotment charge.

The transactions incident to the procurement and disposition of typewriters and other office machines and devices being rather involved, and requiring strict compliance with instructions, the subject of replacement of typewriters will be discussed in detail. During the progress of this discussion reference should be made to the entries recording Survey No. 1–41, T. V. I. No. 1–41, Public Voucher No. 4–1 and A. P. A. Stub No. 54 in the sample forms.

Typewriters for use of the medical department afloat are purchased from funds under the cognizance of the Bureau of Supplies and Accounts while those for use of the medical department ashore are purchased from funds under the cognizance of the Bureau of Medicine and Surgery. Typewriters for use of the medical department afloat are obtained from the supply officer on custody receipt and no medical-department accounting procedures are involved.

The annual estimate from shore stations should contain provision for typewriter replacements and additions because they may not ordinarily be obtained otherwise. Annual contracts are made by the Procurement Division of the Treasury Department with all leading manufacturers of typewriters and the General Schedule of Supplies lists each company's machine and the

contract price for each model by item number. The particular make and model to be purchased is left to the discretion of the activity requiring the machine.

When the replacement of typewriters is authorized in the annual estimate the procedure to accomplish replacement is as follows:

1. Submit a property survey on S. & A. Form No. 154, to the Bureau of Medicine and Surgery, listing only the machines to be replaced. The make, model number, length of carriage in inches, and serial number must be given for each typewriter listed in the request section of the form. No other items should be listed in the survey. In addition to the routine data applicable to all property surveys, a survey of typewriters must contain a statement by the surveying officer or survey board as to whether or not the carriages and main frames are broken. The recommendation should be "To Supply Department for sale or exchange". The appraised value of each typewriter for which replacement is recommended must be stated as the trade-in allowance listed in Class No. 104 of the General Schedule of Supplies for the current year.

2. A specific purchase requisition, original and seven copies of S. & A. Forms Nos. 76 and 76a, shall be prepared and submitted to the Bureau of Medicine and Surgery with the property survey. If the new typewriters are authorized in the annual estimate no letter of transmittal is required. The item number, detailed description, and the contract price as given in the General Schedule of Supplies, as well as the kind of type and size of carriage desired, must be stated for each typewriter requisitioned. The total contract price of all the typewriters requisitioned shall also be stated. Following the entries concerning the last machine requisitioned must be listed: (*a*) The name; (*b*) Model number; (*c*) Serial number; (*d*) General Schedule of Supplies item number and exchange value as shown in Class No. 104; and (*e*) The condition of the carriage and main frame, for each machine to be exchanged on the purchase of the new machines. The total exchange allowance shall be deducted from the total contract price of the new machines to determine the net cost of the requisition. The item number, object and subhead number, and project number, as given in the approved annual estimate, shall be shown following the aforementioned data.

3. Upon receipt of the approved property survey from the bureau the difference between the original book value and the appraised value stated in the survey is expended in the equipment section of the Journal and on the Equipment Ledger sheet. The machine is then transferred, on a Transfer Voucher Issued (S. & A. Form 71), to the nearest supply officer and his signature covering receipt is obtained on the voucher. Upon receipt of the accomplished Transfer Voucher Issued the typewriter value transferred to the supply officer is also expended in the equipment section of the Journal and on the Equipment Ledger sheet. Whether or not the typewriter is retained by the medical department for use pending receipt of the new machine is a local administrative matter. If retained, the typewriter value shall be invoiced to the supply officer as stated before and the supply officer furnished with a custody receipt. The custody-receipt transaction has no effect on the books of account.

4. Upon receipt of the new machine and the invoice, a public voucher is prepared under the Naval Hospital Fund, at naval hospitals, and under the appropriation Medical Department, Navy, at shore stations. The description of the new machine is listed in detail and the contract price is extended to the money value column. Immediately below, in the item column, are inserted the words "Less exchange allowance on (name of) typewriter number ___, surveyed on property survey number ___," and the amount of the allow-

ance is extended in the money value column. The net amount to be paid on the voucher is determined by deducting the exchange allowance from the contract price and is inserted. By reference to the sample forms it will be seen that the contract price is stated on public voucher No. 4–1 as $70.00, the exchange allowance as $15.00, and the net amount of the voucher as $55.00. In the section of the public voucher (Standard Form No. 1034) headed "Accounting Classification" the following information must be recorded: In the first of the four columns from left to right, insert the Navy symbol number and the General Accounting Office symbol and subhead numbers of the appropriation or fund chargeable; in the second column insert the name of the appropriation or fund chargeable; in the third column insert the title and account chargeable (13–X–2 in this case); and in the fourth column insert the net amount chargeable to the appropriation or fund. In the two columns under the heading "Cost Account" is inserted the account number and name of the nearest stores activity to which is attached a supply officer who renders stores returns to the Bureau of Supplies and Accounts. The symbol numbers, subhead numbers, and the name of each appropriation and fund under the cognizance of the Navy Department are stated in the annual Appropriation Bulletin prepared and distributed by the Bureau of Supplies and Accounts. The account number of each naval activity may be found in the List of Accounting Numbers of Ships and Stations published annually by the Bureau of Supplies and Accounts.

5. When the public voucher is "abstracted" to the stores activity by the Bureau of Supplies and Accounts, the supply officer will take up in his Appropriation Purchases Account the net amount paid, in this case $55.00. The supply officer will then have in his Appropriation Purchases Account a total of $70.00, representing the $15.00 taken up from the Transfer Voucher Issued and the amount of $55.00 taken up from the public voucher. It will then be necessary for the medical-department activity to furnish the supply officer with an Appropriation Purchases Account (A. P. A.) stub requisition in the amount of $70.00.

6. At stations, other than naval hospitals, the amount of the A. P. A. stub requisition representing the trade-in allowance on the surveyed typewriter (in this case $15.00) is taken up in the Journal as a *Transfer Voucher Received* and is so reported on line 7 and under the analysis of transfer vouchers received on N. M. S. Form E for the quarter in which received. At naval hospitals the amount of $15.00 is taken up by Journal entry debiting equipment account and crediting transfer vouchers received account, and is so reported on N. M. S. Register No. 3 for the quarter in which received. In either case the amount of $15.00 is entered on the equipment ledger sheet as a receipt from the Supply Department.

7. If a copy of the 13–X–2 public voucher is furnished the medical-department activity, the amount of $55.00 charged to the appropriation is taken up by stations in the Journal, under public vouchers, and is so reported on line 4, and under the summary of public vouchers paid, on N. M. S. Form E and in tables 1, 2, and 4 on N. M. S. Form B for the quarter in which taken up. At naval hospitals the amount of $55.00 charged to the Naval Hospital Fund is taken up in the Charge Register, debiting the amount in the equipment column and crediting the amount in the vouchers payable column, and is so reflected on N. M. S. Register No. 3 and in tables 1, 2, and 4 of N. M. S. Form B for the quarter in which taken up. At either stations or hospitals the amount of $55.00 is entered on the equipment ledger sheet as a receipt by public voucher and this is the only amount of the transaction to be reported as an appropriational expenditure on

N. M. S. Form B under object 32 and subhead 65. The exchange allowance on the surveyed typewriter is taken up as A. P. A. material, at no allotment charge, as the surveyed typewriter was paid for from funds under the cognizance of the Bureau of Medicine and Surgery at the time it was purchased. The A. P. A. stub invoicing the exchange allowance represents typewriter value in the form of the appraised value of the surveyed typewriter previously transferred to the supply officer and taken up by him in his Appropriation Purchases Account. The value is returned on the A. P. A. stub in the form of an allowance on the new typewriter and no charge against an appropriation is incurred by the transaction. To determine the book value of the new typewriter the value of the exchange allowance is added to the amount paid by public voucher.

8. In the event a copy of the 13-X-2 public voucher is not furnished to the medical-department activity the amount charged to the appropriation or fund ($55 in this case) is taken up from the A. P. A. stub requisition following exactly the same procedure as if a copy of the voucher had been furnished.

In conclusion the reader must remember that the scope of this section is limited, and all hospital corpsmen, especially those whose rating subjects them to assignment to duty independent of medical officers or who are assigned to duty in connection with property and accounting, are again reminded that the information contained herein must be supplemented by constant reference to and study of the U. S. Navy Regulations, the Manual of the Medical Department, U. S. Navy, the Bureau of Supplies and Accounts Manual and Memoranda, other bureau manuals, and such instructions relative to this subject as are issued from time to time.

JOURNAL OF RECEIPTS AND EXPENDITURES OF MEDICAL DEPARTMENT PROPERTY
FISCAL YEAR, 1941

RECEIPTS — EQUIPMENT SECTION

Date	(1) Medical Supply Depot	(1) Supply Dept. N.S.A. Material	(1) Public Vouchers	(1) T.V.R. Other M. D. Activities	(1) T.V.R. as A.P.A. Material	Remarks
7-2-40	18.16					S.D. Requisition No. 14-40.Class 7.Reported on supplementary Form B,F.Y.1940
7-15-40	87.15					S.D. Requisition No. 1-41. Class 15
7-18-40				100.00		T.V.R. No.1-41. 10 beds from Naval Hospital, Great Lakes, Illinois.
8-2-40	6.00					Special Issue Requisition No. 15-41. Class 16.
8-15-40					15.00	A.P.A. Stub No.28. Deck Clock. (No allotment charge)
8-20-40			55.00			Public Voucher No. 4-1. Typewriter.
8-31-40		35.00				Stub Summary, August. Fire Extinguishers.
9-20-40			1,250.00			P.V.#876.(Abstracted by Bu.S&A) Buick ambulance, U.S.N. No. 4095.
9-30-40					15.00	A.P.A. Stub No.54. Exchange allowance on typewriter.(No allotment charge)
9-30-40		62.30				A.P.A. Stub No.61. Transportation on Buick ambulance. (Allotment charge)
Totals	111.31	97.30	1,305.00	100.00	30.00	FIRST QUARTER TOTALS, F.Y. 1941
	2	3	4	6	7	Lines on which reported on NMS Form "E"

NOTE: (1) Always taken up in the equipment ledger by individual items, except that transportation charges on equipment are added to the cost of the equipment and the exchange value of typewriters is added to the cost of the typewriters.

JOURNAL OF RECEIPTS AND EXPENDITURES OF MEDICAL DEPARTMENT PROPERTY
FISCAL YEAR, 1941

EXPENDITURES — EQUIPMENT SECTION

Date	(2) Surveys	(2) T.V.I.to Supply Officer for Sale	(2) T.V.I. to other Med.Dept. Activities	Remarks
7-1-40	50.00			Survey No. 1-41, approved by Bu.M&S 6-20-40. (Typewriter)
7-1-40	1,340.00			Survey No. 6-40, approved by Bu.M&S 6-3-40.(Ambulence) Book value $1,390.00
7-9-40		15.00		T.V.I. No. 1-41. Appraised value of survey No. 1-41 (Typewriter)
7-20-40		10.00		T.V.I. No. 2-41. Appraised value of beds on survey No.8-40,approved by BuM&S 6-13-40.
8-30-40			60.00	T.V.I. No.12-40. Lockers to N.A.S.,San Diego, California on 6-12-40.
9-15-40		50.00		T.V.I. No. 3-41. Appraised value of ambulance on survey No. 6-40.
Totals	1,390.00	75.00	60.00	FIRST QUARTER TOTALS, F.Y. 1941
	11	12	13	Lines on which reported on NMS Form "E"

NOTE: (2) Always charge off individual items in equipment ledger.

JOURNAL OF RECEIPTS AND EXPENDITURES OF MEDICAL DEPARTMENT PROPERTY
FISCAL YEAR, 1941

SUPPLIES SECTION

	RECEIPTS (3)	(*)	(*)	(5)	(3)	(3)	
Date	Medical Supply Depot	Supply Dept. N.S.A. Material	Public Vouchers	Pay Roll, Civil Employees	T.V.R. other M.D. Activities	T.V.R. as A.P.A. Material	Remarks
7-5-40			10.00				PV#1-12(40).Special diets,June.Reported on supplementary Form B,FY-1940
7-12-40			76.50				B/L #1087.Memo.voucher.Transportation of remains (T.L.Schmidt).
7-15-40	726.13						S.D. Requisition No.1-41. Classes 6 & 8.
7-15-40				90.00			Pay Roll, 7-1 to 7-15, inclusive
7-15-40			35.00				PV#2-1. Embalming and encasement of T.L. Schmidt
7-31-40		%12.00					Stub Summary,July.Stationery,$5.70. Gasoline,$6.30
7-31-40			20.00				Public Voucher No.1-1. Special diets, July.
7-31-40			22.00				Public Voucher No.1-2. Laundry services, July.
7-31-40				90.00			Pay Roll, 7-15 to 7-31, inclusive
8-3-40					6.00		Transfer Voucher Received No.2-41.Sugar from Naval Hospital,Wash.,D.C.
8-5-40	296.18						S.D. Requisition No.2-41. Classes 1, 2 and 11.
8-10-40			35.00				PV#3-1 (NHF).Hospitalization of D.E.Fox in Memorial Hospital.
8-15-40				90.00			Pay Roll, 8-1 to 8-15, inclusive
8-20-40	18.30						S.D.Reqn.#16-40.Class 13.Reported on supplementary Form B, F.Y.1940.
8-31-40		11.50					Stub Summary, August.Cleaning gear,$1.50.Gas.,Oil & Grease,$10.00.
8-31-40						1.75	A.P.A.Stub Summary,Aug. Pyrex jar for Laboratory.No allotment charge.
8-31-40					10.00		T.V.R.No.3-41.Laundry services from NH,Washington,D.C. (August)
8-31-40				90.00			Pay Roll, 8-16 to 8-31, inclusive
9-2-40			%18.60				PV#1-3. Drugs and Dental supplies purchased during July and August.
9-15-40				90.00			Pay Roll, 9-1 to 9-15, inclusive
9-20-40	178.60						S.D. Requisition No. 3-41. Classes 10,13,17 and 23.
9-30-40			19.25				Public Voucher No.1-4. Special Diets, September.
9-30-40				90.00			Pay Roll, 9-16 to 9-30, inclusive.
9-30-40		22.30					S&A Form 280,September.Work Request #37-41.Painting of ambulance.
9-30-40		12.80					Stub Summary,September.Gas.,Oil & local minor repairs to ambulance.
9-30-40					10.00		T.V.R.#4-41.Laundry services from NH,Washington, D.C. (September)
Totals	1,219.21	58.60	236.35	540.00	26.00	1.75	FIRST QUARTER TOTALS, F.Y. 1941.
	18	19	20	21	23	24	Lines on which reported on NMS Form "E".

NOTES: (3) Always taken up in supplies ledger by individual items.
(5) Maintain one ledger sheet for salaries and one for wages.
(*) Maintain at least one ledger sheet for each expenditure classification as shown in the expenditure section, and in addition, one sheet for civilian medical, dental, nursing and hospital services. Additional sheets should be maintained under each expenditure classification as may be necessary for adequate analysis.
(%) Stationery and Drugs taken up in supplies ledger by individual items.

JOURNAL OF RECEIPTS AND EXPENDITURES OF MEDICAL DEPARTMENT PROPERTY
FISCAL YEAR, 1941

SUPPLIES SECTION

	EXPENDITURES (4)	(4)	(*)	(*)	(*)	(4)	(4)	(*)	(*)	(*)(4)	(4)	(4)	(4)	
Date	Supply Table, Medical	Supply Table, Dental	Special Diets	Laundry	Transport-ation	Misc. Dental Supplies	Misc. M.D. Supplies	Salaries	Wages	Care of the Dead	Survey of Supplies	T.V.I. to Supply Officer	T.V.I. to other M.D. Activities	Remarks
7-5-40			10.00											Special Diets, June, 1940
7-8-40	71.50	6.75					@9.00							Issue Voucher
7-12-40										*76.50				Issue Voucher(Trans.remains-T.L.Schmidt)
7-15-40	76.00	13.50												Issue Voucher
7-15-40								60.00	30.00					Pay Roll, 7-1 to 7-15, inclusive
7-15-40										*35.00				Embalming & encasement (T.L.Schmidt)
7-22-40	63.00	11.15				@2.15	@1.50							Issue Vouchers
7-29-40	75.00	12.20				@1.13	@1.17							Issue Vouchers
7-31-40			20.00	22.00	6.30									Spec.Diets,Laundry,Gasoline (July)
7-31-40								60.00	30.00					Pay Roll, 7-16 to 7-31, inclusive
8-5-40	74.13	5.76					@11.00							Issue Vouchers
8-10-40							*35.00							Hospitalization,D.E.Fox(Memorial Hospital)
8-12-40	62.15	12.70												Issue Vouchers
8-15-40								60.00	30.00					Pay Roll, 8-1 to 8-15, inclusive
8-19-40	72.32	13.02					@2.15							Issue Vouchers
8-26-40	70.15	12.34				@2.16								Issue Vouchers
8-31-40					10.00									Gas.,Oil,Grease (August)
8-31-40				10.00										Laundry Services, August. T.V.R.#3-41
8-31-40								60.00	30.00					Pay Roll, 8-16 to 8-31, inclusive
9-2-40	56.70	13.15					#11.52							Issue Vouchers
9-9-40	72.18	11.12				.27	2.18							Issue Vouchers
9-15-40								60.00	30.00					Pay Roll, 9-1 to 9-15, inclusive
9-16-40	62.76	2.01				.32								Issue Vouchers
9-23-40	51.11	10.57												Issue Vouchers
9-30-40			19.25											Special Diets, September
9-30-40	82.76	13.07				2.16	3.65							Issue Voucher
9-30-40					12.80									Gas.,Oil & minor repairs to ambulance
9-30-40								60.00	30.00					Pay Roll, 9-16 to 9-30, inclusive
9-30-40										125.00				Casket,N.S. (H.B.Smith) Local Burial
9-30-40													1.00	Drugs to U.S.S. KANE. T.V.I. #4-41
9-30-40					22.30									Painting of ambulance. Work Request #37-41
9-30-40				10.00										Laundry Services, September. T.V.R. #4-41
Totals	889.76	137.34	49.25	42.00	51.40	8.19	77.17	360.00	180.00	236.50			1.00	FIRST QUARTER TOTALS, F.Y. 1941
	28	29	30	31	32	33	34	35	36	38	40	41	42	Lines on which reported on NMS Form "E"

NOTES: (4) Charge off individual items in supplies ledger. (*) Maintain one ledger sheet in supplies ledger for each classification so marked.
(@) Miscellaneous supplies expended which were purchased during previous quarters.
(#) Issue Voucher for $11.52 includes $1.50 for cleaning gear and $10.02 for drugs consumed (issued) upon receipt.

STATEMENT OF RECEIPTS AND EXPENDITURES OF MEDICAL DEPARTMENT PROPERTY

U. S. (Name of Station) For Quarter Ended 30 September, 1940

EQUIPMENT (NONEXPENDABLE)

1.	Balance from previous quarter (line 16, last report)				$ 12,934.89
	RECEIPTS DURING QUARTER				
2.	From Medical Supply Depots (charged to S. D. allotment)			$ 111.31	
3.	From Supply Officer, stub requisition and expenditure invoices		$ 97.30		
4.	Public Vouchers (M. & S. Reqn. only)		1,305.00		
5.	Total (lines 3 and 4) (charged to local procurement allotments)			1,402.30	
	TRANSFER VOUCHERS RECEIVED DURING QUARTER				
6.	From other Medical Department activities (S. & A. Form 71)		100.00		
7.	From Supply Officer, A. P. A. material, no allotment charge		30.00		
8.	Total (lines 6 and 7)			130.00	
9.	Total receipts during quarter (lines 2, 5, and 8)				1,643.61
10.	Total (line 1 plus line 9)				14,578.50
	EXPENDITURES				
11.	By approved survey (Equipment only)			1,390.00	
12.	By transfer to Supply Officer for sale		75.00		
13.	By transfer to other Medical Department activities (S. & A. Form 71)		60.00		
14.	Total (line 12 plus 13)			135.00	
15.	Total expenditures (line 11 plus line 14)				1,525.00
16.	Balance to next quarter (line 10 less line 15)				$ 13,053.50

SUPPLIES (EXPENDABLE)

17.	Balance from previous quarter (line 45, last report)				$ 7,652.38
	RECEIPTS DURING QUARTER				
18.	From Medical Supply Depots (charged to S. D. allotment)			$ 1,219.21	
19.	From Supply Officer stub requisitions and expenditure invoices		$ 58.60		
20.	Public Vouchers (M. & S. Reqn. only)		236.35		
21.	From pay rolls, civil employees		540.00		
22.	Total (lines 19, 20, and 21) (charged to local procurement allotments)			834.95	
	TRANSFER VOUCHERS RECEIVED DURING QUARTER				
23.	From other Medical Department activities (S. & A. Form 71)		26.00		
24.	From Supply Officer, A. P. A. material, no allotment charge		1.75		
25.	Total (lines 23 and 24)			27.75	
26.	Total receipts during quarter (lines 18, 22, and 25)				2,081.91
27.	Total (line 17 plus line 26)				9,734.29
	EXPENDITURES				
28.	Supply table *supplies*, medical, expended from storeroom			889.76	
29.	Supply table *supplies*, dental, expended from storeroom			137.34	
30.	Special diets		49.25		
31.	Laundry		42.00		
32.	Transportation service		51.40		
33.	Miscellaneous supplies; dental (other than supply table)		8.19		
34.	Miscellaneous supplies; other (other than supply table)		77.17		
35.	Salaries	$ 360.00			
36.	Wages	180.00			
37.	Total (lines 35 and 36)		540.00		
38.	Care of the dead		236.50		
39.	Total (lines 30, 31, 32, 33, 34, 37, and 38			1,004.51	
40.	By approved survey (supplies only)			0.00	
41.	By transfer to Supply Officer (when authorized)		0.00		
42.	By transfer to other Medical Department activities (S. & A. Form 71)		1.00		
43.	Total (line 41 plus line 42)			1.00	
44.	Total expenditures (lines 28, 29, 39, 40, and 43)				2,032.61
45.	Balance to next quarter (line 27 less line 44)				$ 7,701.68

OPERATING EXPENSE

46.	Gross expenditures (line 15 plus line 44)	$ 3,557.61	
47.	Less nonoperating expenditures (lines 14, 38, and 43)	372.50	
48.	Net operating expense		$ 3,185.11

COMPLEMENT (INCLUDES ALL UNITS)

49.	Average active-duty service personnel during quarter	1,713
50.	Average number of civil employees at station during quarter	870
51.	Average service and civil personnel during quarter	2,583

MEDICAL SERVICES RENDERED CIVILIANS

		Number of individuals	*Number of treatments*
52.	Civil employees	156	1,092
53.	Dependents	425	1,961
54.	Civilians, other (humanitarian)	3	5
55.	Totals	584	3,058

The respective values stated herein as on hand (lines 16 and 45) at the close of the quarter have been verified by actual inventory. The balances of the equipment and supplies ledgers agree with the respective values stated.

A. B. CAST, Commander (MC), U. S. N.
(Medical officer)

FORWARDED:

D. E. GEORGE, Captain, U. S. N.
Commanding.

(SEE REVERSE)

(1) Analysis of Supply Depot Requisitions Received During Quarter:

Requisition No.	Date Received	Equipment	Supplies	Total
S.D.14-40	7-2-40	$ 18.16	$ 0.00	$ 18.16
S.D.16-40	8-20-40	0.00	18.30	18.30
S.D. 1-41	7-15-40	87.15	726.13	813.28
S.D. 2-41	8-5-40	0.00	296.18	296.18
S.D. 3-41	9-20-40	0.00	178.60	178.60
S.I.15-41	8-2-40	6.00	0.00	6.00
Totals,		$ 111.31	$ 1,219.21	$ 1,330.52

(2) Analysis of Stub Requisitions and Expenditure Invoices (Priced) Received During Quarter:

Month	Equipment	Supplies	Total
July	$ 0.00	$ 12.00	$ 12.00
August	35.00	11.50	46.50
September	62.30	35.10	97.40
Totals.	$ 97.30	$ 58.60	$ 155.90

(3) Summary of Public Vouchers Paid, Drawn Against M. & S. Requisitions:

Annual Requisition No.	Equipment	Supplies	Total
1-40 (P.V.#1-12)	$ 0.00	$ 10.00	$ 10.00
1-41 (P.V.#1-1 to 1-4,inc.)	0.00	79.85	79.85
2-41 (P.V.#2-1)	0.00	35.00	35.00
3-41 (P.V.#3-1)	0.00	35.00	35.00
Other than annual requisitions, 4-41 (P.V.#4-1)	55.00	0.00	55.00
5-41 (P.V.#876)	1,250.00	0.00	1,250.00
B/L #1087 (C/D)	0.00	76.50	76.50
Totals,	$ 1,305.00	$ 236.35	$ 1,541.35

(4) Analysis of Transfer Vouchers Received from Other Medical Department Activities During Quarter:

T. V. R. No.	Received from	Equipment	Supplies	Total
1-41	USNH,Great Lakes,Ill.	$ 100.00	$ 0.00	$ 100.00
2-41	USNH,Washington, D.C.	0.00	6.00	6.00
3-41	USNh,Washington, D.C.	0.00	10.00	10.00
4-41	USNH,Washington, D.C.	0.00	10.00	10.00
Totals,		$ 100.00	$ 26.00	$ 126.00

(5) Analysis of A. P. A. Material Received from Supply Officer During Quarter:

Month	Equipment	Supplies	Total
July	0.00	$ 0.00	$ 0.00
August	15.00	1.75	16.75
September	15.00	0.00	15.00
Totals,	$ 30.00	$ 1.75	$ 31.75

(6) Analysis of Approved Surveys During Quarter:

Survey No.	Date approved by Bureau	Value expended by survey	Value to S. O. for sale	Value to M. S. D.	Total value of survey
6-40	6-3-40	$ 1,340.00	$ 50.00	$ 0.00	$ 1,390.00
1-41	6-20-40	50.00	15.00	0.00	65.00
Totals,		$ 1,390.00	$ 65.00	$ 0.00	$ 1,455.00

(7) Analysis of Transfer Vouchers Issued During Quarter:

T. V. I. No.	Issued to	Authority for issue	Equipment	Supplies	Total
12-40	NAS,San Diego, California	BuM&S ltr.(L1-PA) of 5-9-40.	$ 60.00	$ 0.00	$ 60.00
1-41	Supply Officer	App.Survey #1-41	15.00	0.00	15.00
2-41	Supply Officer	App.Survey #8-40	10.00	0.00	10.00
3-41	Supply Officer	App.Survey #6-40	50.00	0.00	50.00
4-41	U.S.S. KANE	BuM&S ltr.(L1-PA) of 9-25-40	0.00	1.00	1.00
Totals,			$ 135.00	$ 1.00	$ 136.00

(8) Analysis of Pay Rolls:

Month	Accrued and unpaid from previous month	Accrued current month	Paid during month	Accrued and unpaid at end of month
July	$ 0.00	$ 180.00	$ 180.00	$ 0.00
August	0.00	180.00	180.00	0.00
September	0.00	180.00	180.00	0.00
Totals.	0.00	$ 540.00	$ 540.00	0.00

Remarks:

Estimated cost of Supply Table supplies consumed in the treatment of dependents of Naval Personnel....... $216.00.

SUPPLEMENTARY
REPORT OF ALLOTMENT EXPENDITURES AND OBLIGATIONS

MONTH
[redacted] ENDED 31 July, 1940.

FROM: U. S. (Name of activity) *Date* 1 August 1940

Table 1. STATUS OF ALLOTMENTS

	Medical Department (1)	Naval Hospital Fund (2)	Care of the Dead (3)	Supply Depot (4)
1. Allotment number	2719	None	3362	1961
2. Annual allotment—plus increases, less decreases	x x x x x x x	x x x x x x x	x x x x x x x	$ 40.75
3. Expenditures previously reported	x x x x x x x	x x x x x x x	x x x x x x x	0.00
4. Apportionment for this quarter	$ 0.00	$ None	$ None	x x x x x x x
5. Obligations brought forward	11.00	None	None	x x x x x x x
6. Total Amount Available	$ 11.00	$ None	$ None	$ 40.75
7. Expenditures this [redacted] month	$ 10.00	$ None	$ None	$ 18.16
8. Obligations unliquidated	Final	None	None	20.75
9. Unexpended balance	1.00	None	None	1.84
10. Total (to agree with line 6)	$ 11.00	$ None	$ None	$ 40.75

Table 2. ANALYSIS OF COMPLETED TRANSACTIONS

	Medical Department	Naval Hospital Fund: Provisions	Naval Hospital Fund: Maintenance	Care of the Dead
1. NSA material (summary NSA stub req. only)	$	$	$	$
2. Work requests (supply officer's S&A 280 only)				
3. Annual req. No. 1-40 (PV# 1-12 [redacted]	10.00			
4. Annual req. No. ...... (PV# ...... to PV# ...... inclusive)				
5. Annual req. No. ...... (PV# ...... to PV# ...... inclusive)				
6. Annual req. No. ...... (PV# ...... to PV# ...... inclusive)				
7. Annual req. No. ...... (PV# ...... to PV# ...... inclusive)				
8. Provision contracts... (PV# ...... to PV# ...... inclusive)				
9. Other charges (list separately):				
(1)				
(2)				
(3)				
(4)				
(5)				
(6)				
(7)				
(8)				
(9)				
(10)				
(11)				
10. Totals	$ 10.00	$ None	$ None	$ None

Table 3. ANALYSIS OF SUPPLY DEPOT REQUISITIONS

(A) Supply Depot Requisitions Received During Current Quarter: Number	Date received	Amount	(B) Requisitions Submitted (Material Not Received): Number	Dated	Estimated cost
S.D. 14-40	7-2-40	$ 18.16	S.D. 16-40	4-28-40	$ 20.75
	Total	$ 18.16		Total	$ 20.75

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ANALYSIS OF ALLOTMENT EXPENDITURES

Table 4. BY OBJECTS AND SUBHEADS

OBJECT AND SUBHEAD (1)	MD ALLOTMENT No. ...... Fiscal year 19.... (2)	NHF ALLOTMENT No. ...... Fiscal year 19.... (3)	C/D ALLOTMENT No. ...... Fiscal year 19.... (4)
TOTALS	None	None	None

RECAPITULATION

Supplies	$	$	$
Equipment			
Land and building			
TOTALS	$ None	$ None	$ None

REMARKS:

A. B. CAST
Commander, Medical Corps, *U. S. Navy.*

Table 5. BY CLASSES AND SUBHEADS

(A) SUPPLIES — SD ALLOTMENT No. ....

S. T. class	Amount	Subhead totals
1	$ 0.00	
2	0.00	
3	0.00	
4	0.00	
SUBHEAD 06		$ 0.00
6	0.00	
8	0.00	
13	18.30	
SUBHEAD 07		18.30
10	0.00	
11	0.00	
18	0.00	
SUBHEAD 08		0.00
23	0.00	
25	0.00	
25a	0.00	
27	0.00	
SUBHEAD 10		0.00
17	0.00	
30	0.00	
SUBHEAD 11		0.00
5	0.00	
SUBHEAD 13		0.00
29	0.00	
SUBHEAD 59		0.00
TOTAL SUPPLIES		$ 18.30

(B) EQUIPMENT

7	$ 0.00	
9	0.00	
12	0.00	
14	0.00	
15	0.00	
19	0.00	
SUBHEAD 60		$ 0.00
22	0.00	
24	0.00	
26	0.00	
SUBHEAD 64		0.00
16	0.00	
SUBHEAD 72		0.00
28	0.00	
SUBHEAD 74		0.00
TOTAL EQUIPMENT		$ 0.00

(C) MORTUARY SUPPLIES AND EQUIPMENT

20	$ 0.00	
SUBHEAD 52		$ 0.00
21	0.00	
SUBHEAD 73		0.00
TOTAL MORTUARY SUPPLIES AND EQUIPMENT		$ 0.00

(D) RECAPITULATION

Supplies	$ 18.30
Equipment	0.00
Mortuary supplies and equipment	0.00
TOTAL RECEIPTS	$ 18.30

U. S. GOVERNMENT PRINTING OFFICE 4—8062

NMS-Form B
(Revised July 1939)

REPORT OF ALLOTMENT EXPENDITURES AND OBLIGATIONS

QUARTER ENDED 30 September, 1940

FROM: U. S. (Name of activity) Date 3 October, 1940

Table 1. STATUS OF ALLOTMENTS	Medical Department (1)	Naval Hospital Fund (2)	Care of the Dead (3)	Supply Depot (4)
1. Allotment number	2376	None	3896	1250
2. Annual allotment—plus increases, less decreases	x x x x x x x	x x x x x x x	x x x x x x x	$ 5,000.00
3. Expenditures previously reported	x x x x x x x	x x x x x x x	x x x x x x x	0.00
4. Apportionment for this quarter	$ 2,175.00	$ 0.00	$ 250.00	x x x x x x x
5. Obligations brought forward	0.00	0.00	0.00	x x x x x x x
6. Total Amount Available	$ 2,175.00	$ 0.00	$ 250.00	$ 5,000.00
7. Expenditures this quarter	$ 2,080.75	$ 35.00	$ 111.50	$ 1,294.06
8. Obligations unliquidated	0.00	0.00	0.00	116.97
9. Unexpended balance	94.25	0.00	138.50	3,588.97
10. Total (to agree with line 6)	$ 2,175.00	$ 35.00	$ 250.00	$ 5,000.00

Table 2. ANALYSIS OF COMPLETED TRANSACTIONS	Medical Department	Naval Hospital Fund		Care of the Dead
		Provisions	Maintenance	
1. NSA material (summary NSA stub req. only)	$ 71.30	$	$	$
2. Work requests (supply officer's S&A 280 only)	22.30			
3. Annual req. No. 1 (PV# 1-1 to PV# 1-4 inclusive)	79.85			
4. Annual req. No. 2 (PV# 2-1xxxxxxxxxxxxxx				35.00
5. Annual req. No. 3 (PV# 3-1xxxxxxxxxxxxxx			35.00	
6. Annual req. No. ..... (PV# ..... to PV# ..... inclusive)				
7. Annual req. No. ..... (PV# ..... to PV# ..... inclusive)				
8. Provision contracts... (PV# ..... to PV# ..... inclusive)				
9. Other charges (list separately):				
(1) M&S Specific Req. No. 4 (PV-4-1)	55.00			
(2) BuM&S Req. #2-41. Cont. No. NOs15673	1,250.00			
(3) Transportation on Equipment	62.30			
(4) B/L No. 1087 (Trans. of remains)				76.50
(5) Civil Payrolls	540.00			
(6)				
(7)				
(8)				
(9)				
(10)				
(11)				
10. Totals	$ 2,080.75	$ 0.00	$ 35.00	$ 111.50

Table 3. ANALYSIS OF SUPPLY DEPOT REQUISITIONS

(A) Supply Depot Requisitions Received During Current Quarter			(B) Requisitions Submitted (Material Not Received)		
Number	Date received	Amount	Number	Dated	Estimated cost
S.D. 1-41	7-15-40	$ 813.28	S.D. 4-41	8-15-40	$ 97.62
S.D. 2-41	8-5-40	296.18	*S.I. 129-41	9-26-40	19.35
S.D. 3-41	9-20-40	178.60			
S.I. 15-41	8-2-40	6.00			
	Total	$1,294.06		Total	$ 116.97

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ANALYSIS OF ALLOTMENT EXPENDITURES

Table 4. BY OBJECTS AND SUBHEADS

Object and Subhead (1)	MD Allotment No. 2376 Fiscal year 1941 (2)	NHF Allotment No. None Fiscal year 1941 (3)	C/D Allotment No. 3896 Fiscal year 1941 (4)
1401	360.00		
1402	180.00		
1406	15.85		
1410	2.75		
1411	5.70		
1412	1.50		
1413	39.25		
1416	22.00		
1418	26.30		
1440	25.10		
1605		35.00	
2250			12.50
2251			76.50
2252			22.50
3265	55.00		
3268	1,312.30		
3269	35.00		
Totals	2,080.75	35.00	111.50

RECAPITULATION

	(2)	(3)	(4)
Supplies	$ 678.45	$ 35.00	$ 111.50
Equipment	1,402.30	0.00	0.00
Land and building	0.00	0.00	0.00
Totals	$ 2,080.75	$ 35.00	$ 111.50

Remarks:

* Invoice received, material not received.

A. B. CAST,
Commander, Medical Corps, U. S. Navy.

Table 5. BY CLASSES AND SUBHEADS

(A) SUPPLIES — SD Allotment No. 1250

S. T. class	Amount	Subhead totals
1	$ 113.92	
2	26.47	
3	0.00	
4	0.00	
Subhead 06		$ 140.39
6	286.48	
8	439.65	
13	59.88	
Subhead 07		786.01
10	18.21	
11	155.79	
18	0.00	
Subhead 08		174.00
23	84.15	
25	0.00	
25a	0.00	
27	0.00	
Subhead 10		84.15
17	16.36	
30	0.00	
Subhead 11		16.36
5	0.00	
Subhead 13		0.00
29	0.00	
Subhead 59		0.00
Total Supplies		$ 1,200.91

(B) EQUIPMENT

S. T. class	Amount	Subhead totals
7	$ 0.00	
9	0.00	
12	0.00	
14	0.00	
15	87.15	
19	0.00	
Subhead 60		$ 87.15
22	0.00	
24	0.00	
26	0.00	
Subhead 64		0.00
16	6.00	
Subhead 72		6.00
28	0.00	
Subhead 74		0.00
Total Equipment		$ 93.15

(C) MORTUARY SUPPLIES AND EQUIPMENT

S. T. class	Amount	Subhead totals
20	$ 0.00	
Subhead 52		$ 0.00
21	0.00	
Subhead 73		0.00
Total Mortuary Supplies and Equipment		$ 0.00

(D) RECAPITULATION

Supplies	$ 1,200.91
Equipment	93.15
Mortuary supplies and equipment	0.00
Total Receipts	$ 1,294.06

U. S. GOVERNMENT PRINTING OFFICE 4—8063

Section 3.—COMMISSARY SUPERVISION

In naval hospitals the department charged with the feeding of patients and of certain staff personnel is termed the *commissary department.* The organization of this department and its personnel, and other matters connected therewith will be discussed in this section.

The **commissary department** of a naval hospital is directly in charge of the *commissary officer* who is assigned to that duty by the commanding officer. Under the supervision of the commanding and executive officer he directs the work of the department, and is responsible for its proper administration.

Section 1635, Chapter 12, Manual of the Medical Department, U. S. Navy, states that the **commissary officer** shall be a chief pharmacist or pharmacist who shall:

1. Be responsible for all commissary stores and provisions, and for all equipment pertaining to the commissary.

2. Be in charge of all personnel assigned to commissary activities.

3. Upon receipt of stores and provisions verify their weights, condition, compliance with specifications and contract requirements; be punctilious in complying with hospital regulations concerning inspection of commissary stores and in event of any items being unsatisfactory notify the executive officer or officer-of-the-day.

4. Exercise strict supervision over upkeep, cleanliness and food handling in galleys, mess halls, store room, diet kitchen and all other commissary activities.

5. Be responsible for all meals, giving unremitting attention to the preparation and service of food and exacting constant attention to economy and cleanliness.

6. Supervise the issue of all commissary stores used at the hospital. The daily issue of stores shall be made in accordance with menus prepared in advance and approved by the executive officer, based on personnel to be subsisted and requirements of approved special-diet lists. Individual rations will be inspected to determine that they are adequate but not excessive.

7. Directly supervise messing facilities and issue special articles of diets, rations, or subsistence in kind upon presentation of accomplished diet sheets or other requisition as may be authorized by the commanding officer.

8. Permit no special mess to be set up without specific authority of the commanding officer.

9. Comply with all regulations and instructions concerning special messes listed in paragraph 1636 so far as they apply to the commissary.

10. Prepare or supervise the preparation of daily Receipt and Expenditure Vouchers for the preceding day, submit them to the commanding officer, via the executive officer, and post them, or cause them to be posted in the commissary ledger.

11. Take an actual inventory of stores and provisions on hand at the end of each month and report in detail to the commanding officer, via the executive officer, any discrepancies between amounts as shown on the books and those found by actual inventory; certify a copy of the inventory to the property and accounting officers as a permanent record.

12. Keep himself informed of regulations and instructions governing the procurement, inspection, storage, and issue of provisions and the proper method of obtaining provisions on contract. Keep a complete file of Navy Department provisions specifications for reference in inspections.

13. When detached or otherwise relieved from duty, make a complete inventory of all commissary stores, provisions, and equipment under his charge and transfer custody thereof to his successor.

ORGANIZATION OF THE COMMISSARY DEPARTMENT

Comprising the commissary department are kitchens, mess halls, storerooms, etc., and the personnel necessary to carry out the work of the department.

Personnel organization.

The personnel of the commissary department assists the commissary officer in the performance of the duties assigned to him and ordinarily consists of hospital corpsmen assigned to this department for duty and of such civil employees as may be allowed as a complement by the Bureau of Medicine and Surgery.

The positions occupied by hospital corpsmen in the organization and their general duties are outlined next.

The *commissary steward*, usually a chief pharmacist's mate, is the chief petty officer assistant of the commissary officer. He is entitled to respect and obedience from all persons of inferior rating and from civil employees in the department. He is responsible for the proper execution of the commissary officer's orders. He may be called upon to prepare the weekly menu for approval of the commissary officer and subsequent approval of the commanding officer. He has general supervision over storerooms, main kitchen, and mess halls. He pays particular attention to garbage collections and food waste, reporting any excessive waste to the commissary officer. He supervises the issue of all provisions and the serving of food in the general mess halls. When provisions are received, he should be present to assist in the inspection thereof, take charge of those accepted, and see that proper disposition is made of them. He should keep the stock records of provisions in the dry provisions storeroom and make estimates of provisions required so that orders or requisitions may be prepared by the clerk for the signature of the commissary and executive officers. He prepares the Receipt and Expenditure Voucher daily, or furnishes the data from which the clerk may prepare it. In the absence of the commissary officer, the commissary steward temporarily assumes the duties of the former.

The *commissary clerk*, usually a pharmacist's mate, is responsible to the commissary officer for all entries made in the commissary ledger; the preparation of orders and requisitions for provisions; the checking of dealer's invoices and the preparation of public vouchers (when prepared by the commissary department) in payment thereof; accomplishing invoices covering provisions received from the supply department; filing and typewriting incident to the commissary department. He may be required to prepare the smooth Receipt and Expenditure Voucher and perform such other special or routine duty as may be assigned to him.

The duties of *storeroom keepers*, usually pharmacist's mates, are as follows: Make all issues of provisions from the issuing storerooms on requisitions approved by the commissary officer or his representative; keep the storeroom clean, orderly and ready for inspection at all times; prepare lists of provisions required to replenish the issuing storeroom from the dry provisions storeroom; and, by daily inventory, keep the commissary steward informed concerning the quantities of nonstock items on hand.

The *mess hall police petty officer*, usually a pharmacist's mate, is responsible for the maintenance of discipline in the mess halls during meal hours; he directs patients, hospital corpsmen, civil employees, and others to their proper mess hall; he receives complaints and reports them to the commissary officer; he assists the storeroom keepers in handling, storing, and issuing provisions; and performs such other special or routine work as may be assigned to him.

If other hospital corpsmen are assigned to the commissary department they usually serve as assistants in the positions that have been listed.

By Executive Order No. 7916 of June 24, 1938, civil employees of the commissary department are included within the classified Civil Service effective February 1, 1939. The ratings of commissary employees are classified as follows:

Group IV (a)	Group III	Group II
Steward. Chief Cook. Chief Mess Attendant.	Baker. Cook. First Cook. Second Cook. Meat Cutter.	Mess Attendants.

For detailed instructions pertaining to civil employees consult circular letter C, Appendix D, Manual of the Medical Department, U. S. Navy.

The positions and general duties of the civil employees of the commissary department are as follows:

When one is employed, the *steward* is the senior civil employee of the commissary department. Under supervision of the commissary officer and/or commissary steward, he has charge of and is responsible for the sanitary condition of the kitchen, bakery, butcher shop, and mess halls, together with the equipment thereof. He may assist in the requisitioning, inspection and issuing of food, and the preparation of menus.

Under the supervision of the commissary officer, commissary steward, or steward, the *chief cook* directs and works with the cooks and assistants engaged in the preparation of food in a large hospital, or is responsible for the entire kitchen, and bakery service of a smaller hospital; he supervises the work incident to cleaning the kitchen, utensils, refrigerators, and other kitchen equipment; he requisitions, issues, and keeps accounts of food and kitchen supplies; and performs all related work as may be required.

First cooks, under supervision of the chief cook, prepare and cook the food. In the smaller hospitals, the senior first cook may be charged with the duties of the chief cook. He supervises the other employees assisting in the preparation of food, and is responsible for the cleanliness of the kitchen, accessory rooms, and the equipment thereof. He may be required to perform related work as deemed necessary.

Second cooks, under immediate supervision, assist in the preparation and cooking of foods; direct and work with other employees engaged in the care and preparation of food for cooking; assist in all kitchen work; serve the cooked food and perform all related work as may be required.

Bakers, under general supervision, bake bread, cakes, and pastry; work with and direct other employees engaged in baking; clean and care for the bakery and its equipment; requisition and account for bakery supplies; and perform such related work as may be required.

The *meat cutter*, under supervision, cuts and prepares meats, fish, and poultry for cooking; works with and directs other employees engaged in meat cutting; requisitions, inspects, stores, and issues such supplies as may be required; cleans, keeps in a sanitary condition, and is responsible for the meat room, tools, refrigerators, and other equipment; and performs all related work as may be required.

It is the duty of the *pantryman*, usually a mess attendant, under supervision, to receive, store, and issue foods used by the hospital kitchens and messes; to keep the storeroom, its equipment and stores in a clean, orderly, and sanitary condition; to keep necessary records; and to perform all related work as may be required.

Chief mess attendants, under supervision, direct and supervise employees or patients engaged in serving food in mess halls, dormitories, and wards, or in ordinary culinary work in connection with serving of food. They are responsible for the appearance and cleanliness of mess halls and the equipment thereof. They perform such additional related work as may be required.

Mess attendants, under immediate supervision, perform ordinary culinary work in the kitchen, pantry, or mess hall, such as: Washing dishes, cleaning and polishing metal utensils, cutlery, and silverware; scrubbing floors, washing walls, windows and woodwork; and assist in the preparation of vegetables and other food for the cook. They serve the prepared food in mess halls, dormitories, and wards; clean the mess halls and equipment; act as yardmen by keeping the garbage cans and the outside area around the kitchen and commissary in a tidy and sanitary condition, and one usually is assigned duty as pantryman.

Physical arrangement.

The *commissary office* should be located in the subsistence building, if such a building exists, or in the immediate vicinity of the commissary department. It should be furnished with sufficient desks, typewriters, and other equipment necessary for the performance of the clerical work of the department, and should have a telephone with city connection. Here are kept the provisions stock ledger, the commissary ledger, the dealers' jacket files, commissary department correspondence file, and other commissary records. All orders and requisitions for provisions are prepared in the commissary office and all matters pertaining to the commissary department are routed through it for appropriate action.

In the *dry provisions storeroom* is kept the reserve stock of dry provisions. It holds from 1 to 3 months' supply of provisions of a character that neither deteriorate rapidly nor require refrigeration. All provisions in this storeroom are considered as unexpended supplies, and are in the same status as are supplies in the medical storerooms. It is the value of this stock, and this stock only, that is determined monthly by physical inventory and is considered as an asset for accounting purposes. The stock of this storeroom is replenished by requisition monthly, or when necessary, on the nearest provision depot of the supply department of the Navy, and by orders placed with contractors under current contracts for special dry provisions not carried in stock in provision depots.

The *issuing storeroom* is usually located in the subsistence building in close proximity to the main kitchen. It is equipped with shelves, bins, and racks for the storage of foods in small quantities for current use. The main hospital refrigerator is considered to be a unit of the issuing storeroom for administrative purposes and is under the charge of a hospital corpsman. All provisions issued to kitchens, butcher shop, messes, wards, etc., pass directly or indirectly through the issuing room. It is restocked by issue from the dry provision storeroom and by deliveries of fresh provisions from the contractors, and issues from it are

made only on the authority of requisitions approved for issue by the commissary officer. The stock carried in the issuing storeroom, having been expended by appropriate entry in the commissary ledger, is not considered as an asset for inventory purposes.

The *main kitchen* is the one in which regular and other diets are prepared. It is a separate section from the mess halls for administrative purposes and is under the immediate supervision of the steward or the chief cook. It includes the kitchen proper, the bakery, the vegetable room, the butcher shop and such other accessory units as may exist and all of the equipment therein. The regular and other diets are distributed from this point.

In the *diet kitchen* food is prepared for the very sick, or others, as may be prescribed by a medical officer. It is usually located in the subsistence building and in the vicinity of the main kitchen. A nurse, especially trained in dietetics, a cook, and mess attendants perform such work as may be required. Hospital corpsmen are often detailed to the diet kitchen for instruction in dietetics. In this kitchen are prepared liquid diets, soft diets, convalescent diets, and, in addition, such diabetic, salt-free, meat-free, or other special diets as may be ordered by the ward medical officers for individual patients. These special diets are distributed from this point to the wards.

The *mess halls* for the general mess are equipped with facilities for serving meals to convalescent ambulatory patients, hospital corpsmen, civil employees, and the Marine guard, if one is attached to the hospital. A chief mess attendant is in charge of the dining-room service and has as many mess attendant assistants as may be required to wait on the tables and to keep the mess halls shipshape. The *scullery* is considered to be a part of the mess hall and is usually in charge of a chief mess attendant. Chief mess attendants work under the supervision of the commissary steward and have no control over the patients or others who eat in the mess halls. A police petty officer is on duty in the main mess hall during meal time to maintain order and enforce observance of the rules and regulations of the hospital.

The *sick officers' mess* is maintained in the sick officers' quarters which are usually provided with a mess room, a kitchen, and a separate force of cooks and mess attendants. Or, lacking these facilities, the food is prepared in the main kitchen or diet kitchen, carried in containers to the sick officers' quarters, and served either in the dining-room or on trays in the patients' rooms.

The *nurses' mess* is conducted in much the same manner as the sick officers' mess, a dining-room and kitchen usually being provided in their quarters for that purpose. Cooks and mess attendants are detailed from the commissary force to the nurses' mess. The housekeeper, under the general supervision of the chief nurse, is in charge. The nurses' mess was given quasi-recognition by the so-called pay bill of 1922 which recites, in part, "From and after July 1, 1922, female nurses are entitled to one subsistence allowance per day, except when on duty and furnished quarters at hospitals and on board ship, when they shall be subsisted in kind, except that when, in the opinion of the commanding officer of a ship, it is considered more desirable," etc. (*See* Appendix A, Sec. C, Par. C–2, S. and A. Manual).

PROCUREMENT, ACCOUNTABILITY, AND EXPENDITURE OF PROVISIONS

Procurement.

The Naval Hospital Fund, (*see* page 779) from which every expense involved in the maintenance of a naval hospital may be paid, provides for the procurement of provisions and articles of special diets consumed at naval hospitals and on hospital ships of the Navy.

Prior to July 1 of each year the Bureau of Medicine and Surgery makes an allotment from the Naval Hospital Fund for the ensuing fiscal year to each naval hospital and hospital ship. These allotments represent limited credits against which public vouchers, stub requisitions, and other intra-Navy transfers may be charged and they constitute the authority for the individual activities to obligate the Naval Hospital Fund to cover such charges.

The allotment of funds being granted, requisitions approved, and contracts awarded, orders may be placed and requests made for deliveries of provisions.

The Bureau of Supplies and Accounts, or its representative, forms a very important link in the procurement of provisions by: Replenishing naval provision depots, preparing joint requisitions for provisions which may be required by local activities, preparing schedules for bidders to furnish provisions (monthly or annually) on a "more or less" basis, awarding contracts to successful bidders and circulating abstracts of contracts showing the various items to be furnished by contractors, preparing and publishing applicable specifications, etc.

Provisions are divided into two classes: Dry provisions and Fresh provisions. Dry provisions are further divided into the subclasses of: Dry provisions, Navy standard and Dry provisions, special. Dry provisions, Navy standard, are those items of groceries that have been standardized by the Navy Department, defined by printed specifications (*see* "Index of Specifications issued by the Navy Department" issued quarterly by the Bureau of Supplies and Accounts) and carried in stock by all naval provision depots. Dry provisions, special, are those items of groceries which are not ordinarily furnished to the "General Service," i. e., ships and stations, but may be obtained for the use of "Hospitals Only."

Fresh provisions are fruits, vegetables, milk, meats, and similar articles which are obtained for early consumption.

In order to obtain fresh provisions and dry provisions, special, it is necessary to furnish the local supply officer a list showing the estimated amounts of these two classes of provisions that will be needed to meet the requirements of the hospital. This list should show the amounts required by months. If the list is prepared properly and carefully and the seasonal rotation of fruits and vegetables taken into consideration, very little difficulty will be experienced in obtaining the various kinds of fresh provisions as they appear in the local markets.

The supply officer makes an annual requisition on the Bureau of Supplies and Accounts for the requirements of the hospital and other naval activities within the district, and upon the approval of that bureau, he makes monthly contracts to furnish these items. After the contracts are made, each activity concerned is supplied with a "Schedule of Provisions Contracts" for the following month. This schedule shows the names, addresses, and telephone numbers of all firms holding contracts during the month, together with the contract numbers and unit prices. In addition to the list of provisions contracted for delivery to the general service, there will be given a list of items for the use of "Hospitals Only." Naval hospitals may order from both lists. The latter list shows such items of dry provisions, special, for hospitals only, as have been included in the original estimate furnished the supply officer and previously referred to.

Orders against these monthly contracts may be made direct to the contractor, using N. M. S. Hospital Form No. 23. The contractor is allowed at least 24 hours' notice before delivery can be required. To obtain either class of dry provisions or other supplies from the local supply officer or commissary store, S&A Form No. 71, a stub requisition, or a letter is used. Local customs vary somewhat in this detail.

Food Inspection.—All fresh provisions procured for use in the commissary department are required to be inspected by the commissary officer to determine

whether or not the articles delivered conform to the following requirements: Agreement with the amounts ordered; delivery at the time stated in the order; in good condition at the time of delivery and fit for human consumption; and in conformity in all respects with the specifications as written into the formal contract or order issued by the supply officer authorizing the transaction. If they conform to requirements they are accepted.

No detailed discussion of requirements and specifications will be made, but a few general rules are given, so that the fundamentals of food inspection may be available.

MEATS.—All items of meats and meat food products are required by naval regulations to be inspected by an inspector of the Bureau of Animal Industry, U. S. Department of Agriculture. The meats are required to be stamped by the inspector and a certificate issued by him stating that the meats or products described on the invoice have been passed by the Department of Agriculture and that they are also in accordance with naval specifications. This certificate is signed by the inspector.

Sex recognition.—The Navy contract specifications for fresh and various other meats exclude from acceptance meats from bulls, boars, stags, and, in most cases, cows. For this reason reference to the recognition of sex in the dressed carcasses has a practical value in this discussion.

"The bull is characterized by the massive development of his muscles, especially the neck and shoulder musculature, also by the dark color of the musculature and the scarcity of fat tissue. Finally the inguinal canal is open.

"The ox (steer) is distinguished from the bull by the weaker development of the shoulder and neck musculature, by its thick panniculus adiposus, and by the possession of a mass of scrotal fat tissue (cod fat) which completely conceals the inguinal ring (a positive and recognizable anatomical point in the hind quarter of all adult males is the ischio-penal ligament, which appears as a circular white fibrous patch in the posterior region of the ischio-pubic symphysis).

"The carcasses of cows are more angular in their various outlines than are those of steer carcasses. There is a marked curvature to the ribs. The cut termed 'round' is flatter; the shanks are thinner, and the mass of 'cod fat' which is seen in the steer is absent in cow carcasses. Very often the udder is carefully removed from fat cow carcasses and fat skewered over the cut surface in order to give them the appearance of steers. This attempted deception, however, is easily recognized by the mammary tissue which remains and by the supramammary lymph glands covering this tissue.

"Close examination will disclose the true character of the small udder on young heifers, which, on account of heavy fat infiltration, resembles the mass of scrotal fat of steers.

"In sheep, the slaughtered buck is distinguished from the ewe and wether by the strongly developed musculature of the neck, withers, and shoulder. The meat of bucks may also possess a disagreeable odor, but, as a rule, this is rare.

"The distinction of importance as regards hogs is between boars and stags on the one hand and sows and barrows on the other. The meat of the boar is coarse and possesses a darker color and the shoulder (or shield) is extremely hard. The meat of the service boar usually has a specific odor best described as a urinous or strong sexual odor. Under the Federal meat inspection regulations, meat or carcasses having this odor are condemned as unfit for food.

"Meat which is suspected of being from a boar or from a recently castrated service boar should be tested for odor. This test is made by placing a sample of meat or raw fat in water in a covered vessel and bringing it to a boil and testing for odor from time to time while heating, or the sample may be heated in a frying pan. In some cases the urinous or boar-sex odor will be found very

pronounced and disagreeable; in others it may be faint, but whenever the odor exists to such degree that its presence can be declared the meat should be rejected as unfit for human food.

"*Characteristics of good meat.*—In all cases the carcass should be that of a well-nourished animal without signs of attenuation or wasting; good meat is firm and elastic to the touch, without œdema or emphysema; that is, does not pit or crackle on pressure. It should be juicy, but not wet nor flabby; the color should be uniform, without brown or discolored patches.

"Good beef is of bright-red color, marbled with fat; veal is always paler and less firm to the touch. Mutton is dullish red and firm, the fat hard and white. In both beef and mutton a uniform yellowness of the carcass may be associated with health conditions. The carcass of the pig should be plump; the flesh is naturally pale and the fat somewhat soft; the skin should not set in folds or wrinkles and should be without stains or blotches. However, slight bruises and scratches are not infrequently present in good carcasses.

"In all cases when sufficient time has elapsed for the carcass to cool and set, the fat of cattle and sheep should be firm and the suet hard, containing no watery jelly or juice, free from blood stains, and creamy white or yellowish in color. The odor should be sweet and agreeable. A skewer thrust deeply into the flesh should have no unpleasant odor when withdrawn.

"The pleura and the peritoneum (the white, shiny membrane lining the chest and thoracic and abdominal cavities) should be free from adhesions and staining and free from evidence that anything has been stripped away; also particular attention should be paid to the connective tissues about the flanks, shoulders, diaphragm, and region of the kidneys; signs of wetness, œdema, imperfect setting, and evidence of disease in the lymph glands should be absent.

"Bull beef, it should be remembered, is usually and normally dark in color, but in other cases marked darkness of the flesh is to be regarded with suspicion." (From Osterhag.)

Fresh meats defined.—The word "fresh," whenever occurring in Navy specifications for meat and meat-food products, is interpreted to include chilled fresh products which are not and have not been frozen. Conversely, products which are, or have been, frozen cannot be accepted as fresh . Meats that have been frozen and subsequently thawed out are dull in color and the blood from it is thin and pale in color (due to separation of the fibrin and serum upon freezing). If a specimen of the blood is mounted on a glass slide and examined under a microscope using a low-power lens the red corpuscles will present a crinkled appearance or the edges will appear scalloped if the meat is or has been frozen.

THAWED-OUT POULTRY.—Frozen poultry that has been thawed out may be detected by the appearance of the lung tissue. If the fowl has been frozen the lung tissue will be dark in color and congested in appearance, but if it has never been frozen the lung will be pink in color and without the congested appearance. The lung from a fresh fowl, if slightly compressed between the fingers, will crackle (due to the air cells bursting under pressure). A thawed-out lung will not give this crackling sensation because the air cells already have been ruptured in the process of freezing.

EGGS.—Every hospital should have "strictly fresh" eggs included on the local monthly provisions contract. The specifications may be very definite or the description "strictly fresh" only may be used. The following discussion will be helpful to those who are not familiar with the distinguishing characteristics of a fresh egg.

Several methods of determining the freshness of eggs have been suggested in various books and pamphlets on the subject, such as placing them in water and

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noting the angle which they assume and whether or not they float. This method depends on the fact that in newly laid eggs the contents fill the egg, and since the specific gravity of the egg is greater than water, the egg therefore assumes a horizontal position at the bottom of the vessel when immersed. Depending on the length of time since an egg has been laid, evaporation of water from the contents through the porous shell will cause it to assume various angles from a horizontal position up to a vertical one. An egg that has lost sufficient moisture so that the specific gravity is less than water will float. Also an egg that has undergone decomposition to such an extent that gases have been liberated within the egg will always float.

This method has the disadvantage of being slow and inaccurate and is not always a true indication of the age of an egg. Eggs that have been placed in cold storage very soon after being laid, provided the storage rooms are kept sufficiently humid, may remain in good condition for several months without sufficient evaporation of contents to make any noticeable difference in the floating angle. On the other hand, they cannot be classed as "strictly fresh" eggs and may have a slightly disagreeable flavor.

It is desirable for every hospital to have an egg-candling device. They may be made in the hospital carpenter shop, or a very satisfactory one may be purchased at little cost. One that can be used in daylight, thereby eliminating the necessity of a dark room, is the most desirable. A suitable type consists of a small sheet-steel box enclosing a 60-watt electric light. There is an opening about 1⅛ inches in diameter in one side of the box, with a shield extension on the top and sides about the opening to exclude rays of daylight. The inside of the shield is painted black to prevent reflected rays from striking the opening. Through the top of the shield is an opening surrounded by another shield similar in shape to the light shield on an ordinary parlor stereoscope. By holding an egg against the small opening and looking down through the upper opening a very clear view of the contents of the egg may be had.

Any shrinkage of the egg is evidenced by an air bubble at one end. The yolk in a fresh egg will show up as a light shadow. A heavy shadow usually indicates that the egg is stale. The various degrees of staleness may be judged by the heaviness of the shadow. A rotten egg always will show black. Hatched eggs are fertile eggs that have been kept in a warm place sufficiently long after laying to start the development of the embryo. This shows up under the candle as a small dark spot.

Broken-yolk eggs are eggs that have been kept in a warm place long enough for the capsule of the yolk to disintegrate through to such an extent that the yolk mixes with the white of the egg. This condition under the capsule appears as a floating shadow throughout the entire contents of the egg rather than being localized, as is the case in a normal egg.

A "strictly fresh" egg should appear under the candle as almost entirely translucent. The only opacity should be the slight shadow cast by a normal fresh yolk. The air bubble should not be over 5 per cent of the egg contents. Eggs that do not meet these requirements should be regarded with suspicion and opened on a saucer. If, after opening, the yolk has a decidedly mottled appearance, does not stand up to almost the shape of a hemisphere, or breaks upon careful opening of the shell, the egg may be considered to be stale. The appearance of the white of the egg is also very helpful in egg inspection. In a fresh egg the white consists of two parts, a viscid, jellylike part and a thin, watery part. In storage eggs that have been held for several months and in stale eggs that never have been in storage but have been held for several days in a warm place the jellylike part of the white disintegrates into a thin, watery fluid.

In the inspection of eggs at a naval hospital one rarely is called upon to differentiate between fresh eggs and eggs that are distinctly rotten, but almost daily one must be able to tell the difference between "strictly fresh" eggs and eggs that are slightly stale. Those that are slightly stale certainly are not "strictly fresh" and therefore should be rejected.

For the purpose of inspecting eggs under a candle the air-cell gauge is very useful. These gauges may be obtained from the United States Department of Agriculture, Washington, D. C.

MILK AND CREAM.—Samples of milk and cream, both thin cream (20 per cent milk fat) and double cream (40 per cent milk fat), should be collected frequently, at least weekly, and sent to the hospital laboratory for analysis. Usually a Babcock test to determine the milk-fat content will be the only test necessary. In collecting samples of milk and cream care should be taken to collect average samples. If the milk is in cans, the milk should be poured from one can to another at least six times, so that the cream will be thoroughly mixed and evenly distributed throughout the milk, and then about a pint collected in a clean bottle as a sample. If the milk is in quart bottles, send a whole bottle to the laboratory. The same precautions should be taken in collecting samples of cream.

FISH.—The inspection of fish is difficult unless the person inspecting it is familiar with the various kinds. A study of a dictionary or a natural history that describes and gives illustrations of the different species of the fish family will prove very helpful. Cheap varieties frequently are delivered for the more expensive kinds; pollock for bluefish, flounder for baby halibut, croakers for Virginia spots, Boston mackerel for Spanish mackerel, etc. Frozen fish that have been thawed out are frequently delivered for fresh-caught fish. Fish that have been frozen lose their delicate flavor. Fresh-caught fish present the following characteristics: The gills are red; the eyes are bright; the blood is bright red, and the flesh is firm. In fish that have been frozen, held in storage and subsequently thawed out, the gills are pale, the eyes dull, the blood dark in color, and the flesh is usually soft with a slightly disagreeable odor, even if it is still edible. To show the points of differentiation between fresh, stale, and putrefied fish, the following table from Meat Hygiene, by Edelmann, Mohler, and Eichhorn, is given.

Condition	Scales	Eyes	Gills	Body in general and meat	Specific gravity
Fresh	Glittering, free from slime, firmly adherent.	Standing out	Gills, lids, and mouth closed.	Solid; placing fish horizontally on the hand it does not bend. Meat firm, elastic, tight on bones.	Sink in water.
Not fresh, stale for some time.	More or less easily removable, slightly slimy or smeary.	Red bordered, sunken; cornea cloudy.	Lids open or can be easily opened; gills pale, yellow dirty, or grayish red, covered with the same kind of fluid; odor disagreeable.	Bony, bends easily, especially at tail end; occasionally bloating of the abdomen, which may be bluish discolored. Finger impressions are easily made, and remain; meat is soft, can be easily removed from the bone.	Float on the water.
Putrefied	Very loose, covered with a smeary, slime-like mass of disagreeable odor.	Breaking down; are frequently removed.	Very off-colored; extremely offensive odor.	Withered, flabby, soft, pale, bloated. The meat is sloppy.	Do.

SHELLFISH.—In the inspection of crabs and lobsters there is but one rule to follow and that is do not accept them unless they are alive. Ptomaines (so-called toxic animal alkaloids) develop very quickly in crabs and lobsters. It should be remembered that the shells of dead oysters and clams are open. The juice of opened oysters and clams should be almost clear and not stringy; any stringy or milky appearance of the juice is a cause for rejection, as it indicates bacterial growth. The oysters and clams should be slightly salty to the taste; a decided fresh taste indicates adulteration by "floating" or by being in direct contact with ice. "Floated oysters" are oysters that have been taken up from their natural beds and either laid down in fresh or brackish water or placed in floats at the mouth of a fresh-water stream for a few weeks. When salt-water oysters are placed in fresh or brackish water the salt in the oyster tissue is dissolved out by the fresh water and the oyster becomes inflated with fresh water (due to osmosis) and increases in size so that when the bivalves are opened the oysterman is enabled to obtain from 10 to 20 per cent more oyster meat from the same quantity of oysters in the shell, thereby increasing his profits at the expense of the innocent purchaser. "Floating" destroys the delicate flavor of the oyster and renders it more liable to contamination by sewage from the stream. Ice in direct contact with the oysters destroys the flavor in the same manner, but does not contaminate the oyster unless the ice itself is contaminated. Clams are not generally "floated."

The inspection of fruit and vegetables will not be discussed, as the standard specifications are very clear and variations from the standards are quite apparent, as almost everyone can distinguish between the good, the indifferent, and the bad.

FOOD ADULTERATION.—The following abstract from the Federal pure food laws will serve as a guide in the inspection of all items of foods, but more particularly in the inspection of dry provisions, special, purchased direct from the contractor, All items of Navy standard dry provisions obtained on requisition from provision depots of the Navy have been inspected at the time of their original purchase by the Navy, and therefore inspection for quantity received is the only inspection necessary when they are received at a hospital.

Adulteration of food consists in practices, some fraudulent, and others technical in nature. Some are injurious to health, but most of them have an economic rather than a sanitary significance.

Methods of adulteration:

1. The removal of nutritive substances.
2. The addition of injurious substances.
3. The fraudulent substitution of cheaper articles.
4. Misbranding.
5. The sale of food that is filthy, decomposed, or putrid.

The more common adulterations are: Cottonseed oil for olive oil; starch or sugar in cocoa and chocolate; caramel, pea meal, or chickory in coffee; cheap fats or cottonseed oil in lard; saccharin for cane sugar; cereals in sausages; bran in flour; oleomargarine as butter; distilled and colored vinegar as pure cider vinegar, etc.

A food is considered adulterated, according to the Pure Food and Drugs Act of 1906—

1. If any substance has been mixed and packed with it so as to reduce or lower or injuriously affect its quality or strength.

2. If any substance has been substituted wholly or in part for the article.

3. If any valuable constituent of the article has been wholly or in part abstracted.

4. If it is mixed, colored, powdered, coated, or stained in any manner whereby damage or inferiority is concealed.

5. If it contains any poisonous or other added deleterious ingredient which may render such article injurious to health.

6. If it contains in whole or in part a filthy, decomposed, or putrid animal or vegetable substance or any portion of an animal unfit for food, whether manufactured or not, or if it is the product of a diseased animal or one that has died otherwise than by slaughter.

7. Misbranding is regarded as a form of adulteration under the Pure Food and Drugs Act.

Accountability.

Immediately upon the receipt, inspection, and acceptance of dry and fresh provisions delivery is completed, title to them passes, and they become the property of the hospital, and the commissary department is held accountable for them. The accountability of the commissary department for provisions includes: The keeping of the necessary accounting records, the storage and preservation of provisions, and such measures as are necessary to insure the economical use of provisions. Accounting procedures will first be briefly discussed.

Deliveries of provisions are accompanied with dealer's bill, S&A Form No. 76, or other invoice. One copy (or more as may be required) is receipted and returned to the vendor or transferor and one copy is retained for internal purposes. It is from these retained copies that the "receipt" portion of the daily Receipt and Expenditure Voucher (N. M. S. Form No. 37) is prepared. The "expenditure" portion of this form is prepared from the records which record issues from the issuing storeroom, through which (for bookkeeping purposes) all provisions are considered to pass. This form is so arranged as to present a daily itemization of all provisions received and/or expended, the quantities involved, the unit cost and extensions. After the preparation of this form, invoices are filed in the appropriate dealer's jacket for future reference.

The receipt of all provisions, regardless of source, is recorded in the commissary ledger. Similarly, all expenditures (issues from the issuing storeroom, including those provisions made available to the messes immediately upon receipt) are also recorded in this ledger. It should be posted daily from the invoices representing receipts and from the expenditure records, i. e.; the daily journal or N. M. S. Form R, whichever may be the local practice, and it is the responsibility of the commissary steward to keep this record posted to date and verified weekly by physical inventory. The receipts and expenditures of provisions are recorded as debits and credits in the Stores Account of the General Ledger of the hospital.

Upon approval by the commanding officer, N. M. S. Form No. 37 becomes an accomplished voucher and a permanent record. It may be likened to a journal entry in a bookkeeping system, inasmuch as it is the supporting voucher for entries of quantities and values in the commissary ledger.

The commissary ledger is a loose-leaf book provided with pages in sets of two and arranged to present quantities and cash values. The page provided for quantity accountability is arranged to present receipts and/or expenditures of accepted units in distinctive columns headed "R" and "E" respectively. In order to distinguish more clearly between the columns, receipts are entered with black ink and expenditures with red ink—positive and negative entries. The page provided for cash values is arranged to present the value of the inventory brought forward, summary values of daily receipts and expenditures, and running totals. The running totals provide a convenient expedient for the control of appropria-

tional expenditures against the provision allotment and a ready means of computing the average per diem cost of the current ration. At the beginning of a month the name, unit, unit cost, number of units on hand, and total value of all items on the inventory are brought forward from the preceding month and entered on new pages of the commissary ledger. Transactions for the current month are then posted chronologically from the approved N. M. S. Form No. 37. After the final transactions of the month have been entered, all columns are summarized, the expenditures deducted from receipts (including the inventory brought forward), and a closing book inventory determined. Quantities and summary values of this inventory must be verified by ference to the provisions stock ledger and by an actual inventory of unexpended stock on hand as of the corresponding date. Adjustments are often indicated due to picking up or dropping fractions. Errors are also discovered at this time and must be corrected or adjusted as may be deemed proper before a final closing inventory is determined and carried forward to the next succeeding month.

The value of inventories is calculated on the average cost basis of items and when new lots of provisions differ in unit cost from those already in stock, a new unit cost price of the combined lots must be made. This price is determined in the following manner: If on a certain date there are in store 6 bags of corn meal valued at $1.00 per bag, and 10 more bags valued at $2.00 per bag are received, the sum of the units and the total value of the combined stock are determined. The latter is divided by the former and a new value per bag is established, which in this instance is $1.625.

When dry provisions are received they should be promptly placed in the dry provisions storeroom, and perishable fresh provisions should be stored immediately in refrigerating rooms in order to prevent deterioration and spoiling.

For the information of the reader there will now be given a brief account of methods used in preserving foods in order to keep them fit for human consumption.

FOOD PRESERVATION.—The methods used in the preservation of foods are: Cold, drying, pickling, smoking, canning, preserving, and chemical treatment.

COLD is an antiseptic rather than a germicide. Low temperatures kill few bacteria, but prevent the growth and multiplication of most of them. No microörganisms pathogenic to man will grow or multiply at the temperature of the refrigerator, but many saprophytic bacteria and molds will, even as low as zero Centigrade. Most pathogenic bacteria withstand freezing, but suffer a quantitative reduction. Most animal parasites die in cold storage. At a temperature of 9° F. trichinæ will die in 20 days. The longer an article remains in cold storage the relatively safer it is. The proper preservation temperature varies for different foods. Meat and poultry for long keeping should be kept frozen at a temperature of 25° F. To keep them for short periods in a chilled condition the temperature should be 33° F. Milk and eggs in the shell are injured by freezing. Fish for long keeping usually are frozen, then dipped in water and refrozen, then stored at 20° F. This coating of ice prevents the loss of water due to surface evaporation.

Articles may be kept in cold storage for a long time; fish for as long as 2 years. Meat, poultry, eggs, and vegetables may be kept for months. Undrawn poultry keeps better in cold storage than drawn, and drawn poultry decomposes more rapidly after removal from the refrigerator.

Cold imparts no new taste nor does it seriously alter the natural flavor. It does not diminish the digestibility nor cause any loss of nutritive value.

DRYING is a primitive method of preserving meats, fruits, vegetables, and other food substances. It furnishes an ideal antiseptic condition, for bacteria require

moisture for their growth, and drying removes this. Furthermore, dried foods usually are cooked before being eaten. It is not adapted as well to meats as to fruits and vegetables. Dried meats lose their natural flavor. Dried eggs and milk keep their nutritive value.

PICKLING is a method of preserving food by submersion in brine, vinegar, or weak acids. When brine is used for pickling it should contain 18 to 25 per cent of salt. Pickling should be considered antiseptic rather than germicidal. Trichinæ die after prolonged pickling.

SMOKING consists in drying food and exposing it to smoke in which certain substances such as acetic acid, creosote, formaldehyde, etc., have been incorporated. These are considered germicidal, but it must be remembered that the penetration is only partial; for example, in smoking sausages, if they are large in diameter, the smoke does not penetrate to the whole of the contents, and they may become dangerous in regard to the various parasites and the products of decomposition contained therein, as smoked meats often are eaten raw.

CANNING is the practical application of the process of fractional sterilization to the preservation of food. Two or more sterilizations are usually made, with a lapse between the sterilizations to permit the germination of spores, which are killed by the subsequent sterilizations. Canned foods are sterile and safer than the fresh article. Fortunately, improperly sterilized canned foods are easily detected by the odors that are produced. Properly canned goods are safe and quite as nutritious as the fresh article.

PRESERVING is a method of preserving food by the addition of sugar and cooking. For this reason the food article must be considered as free from infection. Various acids and salts, such as salicylic acid, benzoic acid, and sodium benzoate, are sometimes employed as chemical preservatives.

CHEMICAL PRESERVATIVES may be considered as antiseptic substances, and not all of them are injurious to the health, the least harmful being benzoic acid and sodium benzoate. Most people object to any chemical or drug substance being used as a preservative.

The chemicals used most commonly are: Benzoic acid and sodium benzoate, borax and boric acid, formaldehyde, salicylic acid, sodium and potassium nitrate, potassium permanganate, sodium fluoride, hydrofluoric acid, sulfites, sodium bicarbonate, hydrogen peroxide, and arsenic.

Expenditure.

Provisions may be expended by issue from the issuing storeroom, by transfer to other activities, or by survey should they become unfit for human consumption.

In order for provisions to be issued from the issuing storeroom the chief cook in the main kitchen, the dietitian in the diet kitchen, the housekeeper in the nurses' quarters, and the person in charge of any other special mess, prepares a food requisition and submits it to the commissary officer every morning. The requisitions are based on the menus prepared in advance, except in the case of the diet kitchen. The requisitions should call for sufficent food for three meals—supper, and breakfast and dinner for the following day. After the requisitions are approved by the commissary officer they are sent to the issuing storeroom for issue at stated hours. The hours of issue should be arranged so that they operate to the best advantage, both to the section drawing the provisions and to the commissary department. All eggs, oranges, milk, cream, etc., issued to the wards on request should be issued by the issuing storeroom and through the diet kitchen. No uncooked food should be issued to any section or hospital department, except by the method outlined. In other words, all food is issued through the issuing storeroom, and no food is issued from there except upon the

authority of a requisition signed by the commissary officer. This permits the commissary officer to have absolute control over all issues of food.

When provisions are expended by survey the survey in most cases is an informal one. (*See* page 784). The value of the provisions surveyed is charged to the cost of the ration.

Should provisions be transferred to other activities the procedures are as described in the section on Hospital Supplies and Property Accountability.

Issues of provisions to the chief cook are principally made to meet the requirements of the menu for the general mess and of regular diets. In the issue and economical use of provisions the menu is an important factor and will now be discussed.

Menus and their preparation.—Menus are prepared for as many classes of diets as may be necessary and in preparing them S&A Form No. 333 usually is used. They should be prepared not later than Tuesday of each week for 7 days, Monday to the following Sunday, and be submitted to the commanding officer for approval, via the executive officer.

After being approved, menus should not be changed except for some very good reason, such as inability to obtain certain articles of provisions, etc.

Regular-diet menus only will be discussed in this section. For a discussion of soft diets, convalescent diets, and special diets, *see* chapter on Diets and Messing for the Sick. The points to be kept in mind in preparing regular diet menus are: First, to serve sufficient food to satisfy body requirements; second, to prepare food that is pleasing to the senses, thus stimulating the appetite; and third, to do these economically.

A proper regular-diet menu should be changed every week to give it variety. No matter how carefully a menu is planned or how well the food is cooked and served, if it is repeated too often indifference or aversion may result. Most persons will tire of chicken and ice cream in the same manner as they do of stew and prunes if repeated at short intervals. In the interest of digestive functions and proper metabolism, different kinds of foods should be served in such proportion that the various food-stuffs, i. e., protein, fats, and carbohydrates, are ingested in approximately the proportion of one part of fat, two parts of protein, and eight parts of carbohydrates. A lack of the proper food elements in a diet may cause "food deficiency diseases" such as scurvy, pellagra, and beriberi.

It has been found that man does his best when he ingests animal and vegetable food in the proportion of about 20 per cent animal and 80 per cent vegetable.

A man requires from 3,000 to 5,000 calories of foodstuffs per day in the proportion given above, and knowing that 1 Gm. of protein yields approximately 4 calories, 1 Gm. of fat approximately 9 calories, and 1 Gm. of carbohydrates approximately 4 calories, the caloric value of menus should be computed from time to time in order to check the caloric sufficiency of the diet.

When uncooked rations are being served on the basis of a well-balanced ration, quantities should be issued in excess to allow for waste. Experience has shown that waste, such as loss in peeling potatoes, food left on plates, etc., can be kept down to about 20 per cent. If the principles of a well-balanced ration are observed food will not be wasted to any great extent by being left on plates.

It may be advantageous to work up a menu by first arranging the dinners for each day, starting in with the meats and building around that main dish. By first deciding what meat to have for each day's dinner, it is easier to obtain a rotation in meats, and it also enables one to work in left-over portions for suppers and breakfasts.

In addition to the required amounts of ordinary meats, starchy vegetables, cereals, beverages, etc., some article of fresh fruit, preferably raw, and also some variety of green leafy vegetable should appear each day on the menu. In summer the selection of these articles is comparatively easy, but in winter most of them are too expensive for routine use. The following list is suggested, from a combined food value and economic point of view, for use in the late fall, winter, and early spring. Fresh fruits, such as oranges, lemons, grapefruit, apples, bananas, and fresh vegetables, such as tomatoes, spinach, lettuce, cabbage, string beans, carrots, and cauliflower.

A good rule to follow in preparing menus is never to open a can when the same article of food is procurable in the market in its fresh condition, provided the fresh article can be purchased at a reasonable price and the personnel of the commissary department has the time to prepare it. It takes more time and labor to prepare fresh articles for serving than it does to open cans, and it is very much easier for the cooks to open cans than it is to get the mess attendants to prepare the fresh articles. Consequently, the kitchen requires constant supervision by the commissary officer to prevent the substitution of canned goods from the dry-provision storeroom for fresh provisions when the latter has been procured for the menu. Then, if it is intended to have fresh string beans for a certain meal the words "fresh string beans" should be written on the menu and not the words "string beans."

The color combinations of foods presented when the finished meal is on the plate should be considered in preparing menus. Avoid a similarity of color so far as practicable, as a variety of colors stimulates the appetite. A dinner consisting of cream of potato soup, roast pork, mashed potatoes, stewed dried lima beans, vanilla ice cream, and bread would all be white in color. If the soup were changed to vegetable soup, the lima beans to tomato salad, apple sauce served with the roast pork, and the vanilla ice cream changed to chocolate, the color monotony would be broken.

In order to have a standard as a basis for the caloric or fuel value in preparing menus at hospitals the caloric value of a "fresh provision," U. S. Navy ration, given in Gatewood's Hygiene as 3,563 calories per day per man, may be taken. It must be understood that the average caloric value for all food consumed in a hospital will be greater than this figure because of the special diets, special messes, and for other reasons. Accepting this standard for the regular diets, the U. S. Navy ration table, as given in the Bureau of Supplies and Accounts Manual, article 1320, may be used as a basis for comparative purposes. For instance, 1¾ pounds of fresh meat per day per man is allowed; also 1¾ pounds of fresh vegetables, 2 ounces of butter, 4 ounces of sugar, etc. By computing the amounts of the various items of provisions used in a hospital a very accurate idea may be had of whether or not excessive amounts of the various items of foods are being used in the menus.

The table given herewith is based on information contained in bulletin No. 28 of the United States Department of Agriculture, The Chemical Composition of American Food Material; Diet in Health and Disease, by Friedenwald and Ruhräh; and Feeding the Family, by Rose.

No claim is made for mathematical accuracy in presenting this table, as the matter of standardization of weights and measures is exceedingly difficult, especially when an attempt is made to make them agree with average portions. It is believed, however, that this table will be found useful in balancing menus, so that they may be kept somewhere near the standard selected—that of 3,563

calories per day per man. Where no figures appear in the tables, data are not available on which to base computations.

"Average portions" as referred to in the table are considered to be the average amounts required or expected by the average man of good health at one meal in the general mess at naval hospitals.

The abbreviations used in the table are explained as follows:

tsp	teaspoonful.	lb	pound.
tbsp	tablespoonful.	qt	quart.
lge	large.	sl	slice.
med	medium.	pc	piece.
sml	small.	av	average.
dia	diameter.		

TABLE OF FOODS USUALLY FOUND ON NAVAL HOSPITAL MENUS, SHOWING SIZE OF AVERAGE PORTIONS EXPRESSED IN COMMON HOUSEHOLD MEASURE, WEIGHTS OF PORTIONS, CALORIC VALUES, AND PERCENTAGE OF PROTEINS, FAT, AND CARBOHYDRATE CALORIES

BEVERAGES

		Ounces	Calories	Protein	Fat	Carbohydrate
Cocoa (1 cup milk, 2 tsp. cocoa, 2 tsp. sugar).	1 cup	9.5	250	16	44	40
Eggnog	1 cup	7.4	200	21	48	31
Lemonade	1 cup	7.0	70			100
Coffee	1 cup	8.0	0			
Tea	1 cup	8.0	0			

BREADS, BISCUITS, MUFFINS

NOTE.—Add 160 calories to caloric values of breads, etc., listed, if butter (0.8 oz.) is served with th breads.

		Ounces	Calories	Protein	Fat	Carbohydrate
Baking powder biscuits	2 sml. biscuits	1.3	100	11	27	62
Bread, Boston, brown	1 sl. ¾" x 3" dia	1.8	100	10	10	80
Bread, graham	3 sl. ⅜" x 2" x 3¼"	1.4	100	14	6	80
Bread, corn, old New England	1 pc. 2½" x 2" x 1"	2.0	200	8	30	62
Bread, white	2 sl. 4" x 4" x ½"	1.6	100	14	6	80
Bread, whole wheat	2 sl. 2½" x 2¾" x ½"	2.8	200	16	3	81
Bread, corn cake	2 sl. 2" x 2" x 1"	2.4	200	10	24	66
Oyster crackers	24 crackers	.8	100	10	22	68
Saltines	6 crackers	.8	100	10	26	64
Soda crackers	4 crackers	.9	100	10	20	70
Croutons (toasted)	15 croutons, ½" cubes	.8	100	7	49	44
Griddle cakes	3 cakes, 4½" dia	5.4	300	14	25	61
Muffins, cornmeal	2 muffins	3.2	266	13	25	62
Sandwich, club	1 sandwich	9.0	600	15	69	16
Toast, cream	1 sl. with ¼ cup sauce	3.6	165	13	43	44
Toast, French	2 sl. 3" x 3" x ½"	2.8	200	10	48	42

CAKES, ETC.

		Ounces	Calories	Protein	Fat	Carbohydrate
Angel cake	1 pc. 1¼" x 2" x 2½"	1.3	100	12	1	87
Apple sauce cake	1 pc. 1½" x 3¾" x 1"	1.6	200	5	11	84
Chocolate loaf	1 pc. 2½" x 5" x ⅞"	1.8	200	5	41	54
Doughnuts	1 doughnut	1.6	200	6	45	49
Fruit cake	1 pc. 1⅞" x 1⅞" x ¾"	1.8	200	6	26	68
Gingerbread	1 pc. 2" cube	2.4	200	8	22	70
One-egg cake	1 pc. 1¾" x 1¾" x 3½"	2.0	200	8	32	60
Cookies, plain	3 cookies 2½" dia	2.7	150	6	33	61
Sponge cake	1 pc. 1½" x 1½" x 2"	.9	100	11	19	70
Icing, "White Mountain"	1½ tbsp	.5	50	1		99

SUGARS AND SYRUPS

		Ounces	Calories	Protein	Fat	Carbohydrate
Maple syrup	1½ tbsp	1.2	100			100
Molasses	1½ tbsp	1.2	100	3		97
Sugar, white, granulated	2 tbsp. (scant)	.9	100			100
Sugar, white, powdered	2 tbsp	.9	100			100
Sugar, brown	2 tbsp	.9	100			100

Table of Foods Usually Found on Naval Hospital Menus, Etc.—Continued

Cereals

Note.—Add 100 calories to caloric value of any cereal given to allow for milk (4 oz.) and sugar (2 tsp.) if served.

		Ounces	Calories	Protein	Fat	Carbohydrate
Cornflakes	1 cup	0.8	80	6	4	90
Cornmeal, cooked	⅔ cup	6.0	100	10	5	85
Farina	¾ cup	6.0	100	12	4	84
Grapenuts	3 tbsp	1.0	100	12	2	86
Hominy grits, cooked	⅘ cup	6.8	100	9	1	90
Macaroni, cooked	1 cup	5.2	100	15	2	83
Macaroni croquette	1 croquette	1.2	100	10	45	45
Macaroni, tomato sauce	5 tbsp	3.6	100	10	36	54
Oatmeal, cooked	1 cup	7.9	100	17	16	67
Puffed Rice	1⅓ cups	1.0	100	9	1	90
Puffed Wheat	1¾ cups	1.0	100	15	3	82
Rice, steamed	¾ cup	4.0	100	9	1	90
Shredded Wheat	1 biscuit	.9	100	13	5	82

Puddings, Ice Creams, Etc.

Apple tapioca	½ cup	7.2	200	1	1	98
Boiled custard	⅘ cup	6.6	300	13	44	43
Brown Betty	½ cup	5.0	250	3	35	62
Bread pudding, raisin	½ cup	5.0	250			
Cornstarch, blanc mange	½ cup	5.4	200	8	33	59
Cottage pudding	1 pc. 2″ x 2½″ x 1¾″	1.1	100	7	26	67
Custard pudding	⅔ cup	6.6	200	17	39	44
Lemon ice	½ cup	3.1	100			100
Lemon jelly	½ cup	3.8	100	9		91
Lemon milk sherbet	½ cup	3.8	200	4	12	84
Peach ice cream	⅙ qt	3.0	180	4	51	45
Prune soufflé	½ cup	2.2	125	10		90
Raspberry sherbet	½ cup	4.2	200	1		99
Rice pudding, raisins	½ cup	2.0	120	12	27	61
Snow pudding	⅔ cup	2.2	100	10		90
Vanilla ice cream (1 qt. 20 per cent cream; ¾ cup sugar; 1½ tbsp. vanilla extract).	⅙ qt	3.2	200	4	63	33

Dairy Products

Butter	⅒ lb	0.8	160	1	99	
Cheese, American, full cream	1 pc. 2″ x 1″ x ⅜″	.9	100	25	72	3
Cheese, cottage	2 tbsp	1.2	40	76	9	15
Cream, 20 per cent	2 tbsp	.25	25	5	86	9
Cream, 40 per cent	1 tbsp	.7	75	2	95	3
Cream, whipped	1 tbsp	.45	50	2	95	3
Milk, condensed	1 tbsp	.7	65	11	23	66
Milk, evaporated	1 tbsp	.5	25	23	51	26
Milk, fresh	1 cup	8.1	160	19	52	29

Eggs and Cheese Dishes

Eggs, raw	2 eggs	4.0	150	36	64	
Eggs, scrambled	½ cup	4.2	200	20	76	4
Macaroni and cheese	½ cup	2.1	100	17	39	44
Welsh rarebit	3 tbsp. rarebit and 1 sl. toast	2.6	200	22	57	21

Fruits

Apple, baked, with 2 tbsp. sugar.	1 med. sized apple	3.5	150	1	3	96
Apple, baked, with cream	1 med. sized apple	5.0	200	1	31	68
Apple, fresh, raw	1 med. sized apple	5.0	65	3	5	92
Apple sauce	⅜ cup	3.5	100	1	3	96
Apricots, canned	3 lge. halves with 2 tbsp. juice.	4.8	100	5		95
Apricots, dried, stewed	¼ cup	2.7	100	4	2	94
Bananas	1 med. sized banana	4.5	80	5	6	89
Blackberries, fresh	1 cup	12.2	200	9	16	75
Blackberries, stewed	½ cup	4.4	200	2	4	94
Cantaloup	½ melon, 4½″ dia	9.0	50	6		94
Cranberry jelly	2 tbsp	1.5	100		1	99
Cranberry sauce	½ cup	1.5	100		1	99

TABLE OF FOODS USUALLY FOUND ON NAVAL HOSPITAL MENUS, ETC.—Continued

FRUITS—Continued

		Ounces	Calories	Protein	Fat	Carbohydrate
Grapefruit	½ large	6.0	80			
Grape juice	¼ cup	3.5	100			100
Grapes, Concord	1 lge. bunch	4.9	100	5	15	80
Grapes, Malaga	22 grapes	3.7	100	5	15	80
Huckleberries, fresh	1 cup	4.7	100	3	7	90
Lemons	1 large	3.8	35	9	15	76
Olives, green	3-4 olives	.8	50	1	83	16
Oranges	1 large	9.5	100	7	2	91
Peaches, fresh	3 medium	10.5	100	6	3	91
Peaches, canned	2 lge. halves and 3 tbsp. juice	7.5	100	6	2	92
Peaches, stewed	½ cup	3.5	100	2		98
Pears, fresh	2 medium	6.3	100	4	6	90
Pears, canned	2 halves and 2 tbsp. juice	3.0	65	2	4	94
Pineapple, canned, sliced	1 sl. and 3 tbsp. juice	2.3	100	1	4	95
Pineapple, fresh	1 sl. 1″ thick	4.1	50	4	6	90
Plums, fresh	2 large	2.2	50	5		95
Prunes, stewed	4 prunes and 4 tbsp. juice	5.6	200	2		98
Raisins	¼ cup	1.1	100	3	9	88
Raspberries	1 cup	5.0	90	10	14	76
Rhubarb	½ cup	1.7	100	1	2	97
Strawberries, fresh	1 cup	6.6	75	10	14	76
Watermelon, edible portion	Large portion	11.7	100	5	6	89

MEATS, COOKED

		Ounces	Calories	Protein	Fat	Carbohydrate
Beef, corned (less ¾ fat content).	1 sl. 4½″ x 1½″ x ⅝″	3.0	100	53	47	
Beef, dried, creamed	⅓ cup	2.3	100	20	62	18
Beef, hamburger steak, broiled	2 cakes, 2½″ dia. x ⅞″ thick	4.0	200	55	45	
Beef, heart, stuffed	2 sl. 2½″ x 2¼″ x ¼″	2.0	200	21	68	11
Beef, loaf	1 sl. 4″ x 6″ x ¼″	3.0	200	40	60	
Beef, pie	1 serving	6.8	400	10	43	47
Beef, rib, lean, roasted	1 sl. 5″ x 5″ x ¼″	3.2	200	46	54	
Beef, round, lean, boiled	1 serving	3.3	150	90	10	
Beef, round, lean, pot roast	1 serving	3.3	200	62	38	
Beef, round steak, pan broiled	1 pc. 4″ x 6″ x 1⅛″	4.0	200	48	52	
Beef, sirloin, med. fat, broiled	1 pc. 4½″ x 1¾″ x ¾″	4.0	300	31	69	
Beef stew with vegetables	1 cup	7.5	250	16	45	39
Frankfurters	2 sausages	2.2	200	31	67	2
Lamb chops, broiled	2 chops, meat portion, 2″ x 2″ x ½″.	3.8	200	40	60	
Lamb, leg, roast	1 sl. 3½″ x 4½″ x ¼″	3.6	200	41	59	
Mutton, leg, roast	1 sl. 3″ x 3¾″ x ⅜″	3.6	300	33	67	
Pork (bacon)	4-5 sml. sl	.5	100	13	87	
Pork (ham, boiled)	1 sl. 4¾″ x 4″ x ⅛″	2.6	200	29	71	
Pork, loin, roast	1 serving	4.0	300	33	67	
Pork, loin chop	1 chop	4.0	250	33	67	
Pork sausage, broiled	3 sausages, 3″ long, ¾″ dia	2.2	200	20	78	2
Poultry:						
Chicken, broiled	¼ of av. 1½ lb. broiler	3.2	100	80	20	
Chicken, roast	1 serving	4.0	250	51	49	
Turkey, roast	1 serving	4.0	340	40	60	
Poultry stuffing	⅓ cup	1.6	200	9	48	43
Veal cutlets, breaded	1 serving	5.0	250	30	52	18
Veal, leg, roast	1 sl. 2″ x 2¾″ x ¼″	5.0	250	71	29	
Veal (liver, calf)	1 serving	4.2	200	47	53	
Irish stew with dumplings	1 cup with 1 dumpling		450			
Hash, fresh, 50 per cent meat, 50 per cent potatoes.	1 cup	12.0	350			

FISH AND SHELLFISH

		Ounces	Calories	Protein	Fat	Carbohydrate
Bluefish	1 serving	3.8	150	72	28	
Codfish balls	2 balls, 2″ dia	3.4	200	14	65	21
Codfish, creamed	½ cup	2.5	100	32	46	22
Halibut steak, broiled	1 pc. 3″ x 2¼″ x 1″	3.0	100	61	39	
Mackerel, Spanish, broiled	1 serving	3.9	150	56	44	
Salmon, canned	½ cup	2.0	125	45	55	
Salmon, creamed, on toast	½ cup salmon and 1 sl. toast	4.8	200	22	42	36
Salmon, loaf	½ cup	4.2	200	37	52	11
Sardines, canned	3-6 sardines	1.7	100	46	54	
Clams	6 clams or ⅓ cup	7.6	100	56	8	36
Lobster, canned	½ cup	2.8	65	86	12	2
Oysters	⅔ cup or 6-15 oysters	7.2	100	49	24	27
Shrimp	½ cup	3.2	100	91	8	1

Table of Foods Usually Found on Naval Hospital Menus, Etc.—Continued

PIES

Apple	⅙ of a 9″ pie	4.8	300	3	41	56
Cranberry	⅙ of a 9″ pie	4.8	340	2	18	80
Custard	⅙ of a 9″ pie	4.3	225	9	32	59
Lemon meringue	⅙ of a 9″ pie	4.5	450	5	27	68
Mince	⅙ of a 9″ pie	5.4	450	8	39	53
Raisin and cranberry	⅙ of a 9″ pie	4.5	450	3	27	70
Rhubarb	⅙ of a 9″ pie	5.0	300	5	18	77
Squash	⅙ of a 9″ pie	4.0	225	10	25	65
Pumpkin	⅙ of a 9″ pie	4.0	200	10	25	65

SALADS AND DRESSINGS

Banana salad	1 serving	4.0	150	12	36	52
Cabbage salad	½ cup	1.4	50	6	78	16
Cheese and pineapple salad	1 serving	3.4	200	9	58	33
Chicken salad	1 serving	3.2	200	12	86	2
Egg salad	1 serving	3.5	250	14	85	1
French dressing	1½ tbsp	.6	100		100	
Fruit salad	½ cup and 1 tbsp. dressing	3.0	200	3	75	22
Lettuce salad with French dressing.	1 serving	2.4	200	1	95	4
Mayonnaise dressing	1 tbsp	.5	100	1	97	2
Potato salad	1 serving	3.4	200	3	68	29
Tomato and cucumber salad	1 serving	3.0	150	4	81	15
Tomato and lettuce salad	1 serving	5.4	200	3	86	11
Waldorf salad	1 serving	3.0	250	4	76	20

SOUPS

Asparagus, cream of	1 cup	8.0	100	17	56	27
Bouillon	1 cup	8.0	25	84	8	8
Celery, cream of	1 cup	7.2	200	11	61	28
Corn, cream of	1 cup	7.8	200	12	38	50
Green pea, cream of	1 cup	7.8	150	16	46	38
Oyster stew	1 cup	9.0	200	16	63	21
Potato	1 cup	8.5	200	15	38	47
Split pea	1 cup	10.0	250	26	2	72
Tomato	1 cup	9.0	135	12	12	76
Tomato, cream of	1 cup	8.5	260	11	63	26

VEGETABLES

Asparagus	5 lge. stalks, 8″ long	4.0	25	32	8	60
Beans, baked	1 cup	8.0	300	21	18	61
Beans, kidney, stewed	½ cup	4.9	100	26	18	56
Beans, lima, dried	⅛ cup	1.0	100	26	5	69
Beans, string	1 cup	3.6	45	22	7	71
Beets	1 beet, 2″ dia	2.0	25	14	2	84
Cabbage	1 cup	2.0	20	20	9	71
Carrots	1 young carrot, 4″ long	2.0	20	10	5	85
Cauliflower	¼ of small head	2.0	20	23	15	62
Celery	1 serving	1.0	6	24	5	71
Corn, a la Southern	⅓ cup	3.4	100	16	41	43
Corn, canned	⅓ cup	3.6	100	11	11	78
Corn on cob	2 ears, 6″ long	9.0	100	12	9	79
Cucumbers	½ cucumber, 7″ long	2.4	10	19	12	69
Lettuce	1 serving	1.0	6	25	14	61
Onions, raw	1 medium	2.0	25	13	6	81
Onions, fried	1 serving	3.0	60			
Onions, escalloped	⅓ cup	2.5	100	8	59	33
Peas, canned	½ cup, drained	3.0	65	26	3	71
Peas, creamed	½ cup	2.7	100	18	37	45
Peppers, stuffed, meat and bread crumbs.	1 pepper	6.0	250	11	21	68
Potatoes, sweet, baked	1 medium	6.0	200	6	5	89
Potatoes, sweet, candied	1 small	4.0	200	4	7	89
Potatoes, white, baked	1 large	5.0	165	11	1	88
Potatoes, white, boiled	1 large	5.4	150	11	1	88
Potatoes, white, creamed	⅘ cup	5.4	200	9	50	41
Potatoes, white, mashed	1 cup	6.0	200	7	48	45
Potatoes, white, escalloped	⅝ cup	3.5	100	9	30	61
Potatoes, white, fried	1 serving	5.0	200			
Radishes, red, turnip	6 medium	2.0	16	18	3	79
Spinach, boiled	1 cup	8.0	40	12	8	80
Spinach, boiled with egg	⅘ cup	7.6	100	10	70	20
Succotash	½ cup	5.3	150	15	9	76
Tomatoes, canned	½ cup	4.4	30	21	8	71
Tomatoes, fresh	1 medium	5.0	35	16	16	68
Tomatoes, stuffed	1 tomato	4.0	100	13	45	42
Turnips, creamed	½ cup	1.4	100	13	5	82

Table of Foods Usually Found on Naval Hospital Menus, Etc.—Continued

Miscellaneous

		Ounces	Calories	Protein	Fat	Carbohydrate
Nuts, mixed	1 serving (estimated)	1.0	200	10	82	8
Coconut, prepared	⅕ cup	.6	100	4	77	19
Peanut butter	2½ tsp	.6	100	19	69	12

Sample Winter Menu for the General Mess, Showing Approximate Caloric Values of the Items

Day	Breakfast		Dinner		Supper	
Monday	Corn flakes and milk	180	Roast loin of pork	300	Boston baked beans	300
	Hamburger steak	200	Boiled sweetpotatoes	200	French-fried potatoes	150
	Baked potatoes	165	Fresh apple sauce	100	Fruit salad	200
	Corn bread and butter	360	String bean and lettuce salad	100	Brown bread and butter	260
	Coffee		Pumpkin pie	200	Tea and milk	160
			Bread, butter, coffee	260		
		905		1,160		1,070
Tuesday	Baked apples and cream	200	Porterhouse steak, gravy	300	Oyster stew	200
	Pork sausage	200	Fried onions	60	Crackers	100
	Griddlo cakes	100	Mashed potatoes	200	Cold sliced meats	200
	Maple syrup	100	Celery		Potato salad	200
	Bread, butter, coffee	260	Custard pudding	200	Spiced pears	100
			Bread, butter, coffee	260	Bread and butter	260
					Cocoa	250
		860		1,020		1,310
Wednesday	Shredded wheat and milk	200	Cream of tomato soup	260	Meat croquettes	250
	Fried eggs	150	Roast lamb, mint sauce	200	Creole rice	100
	Fried bacon	100	Roast brown potatoes	165	Cabbage salad	50
	Hot rolls and butter	260	Stewed canned peas	65	Brown Betty pudding	250
	Coffee		Lemon sherbet	100	Bread, butter, tea	260
			Bread, butter, coffee	260		
		710		1,050		910
Thursday	Oranges	100	Chicken potpie	300	Pork chops	300
	Creamed chipped beef on toast	300	Baked sweetpotatoes	200	Cottage fried potatoes	150
	Fried potatoes	120	Baked squash	100	Combination salad	200
	Coffee		Fruited rice pudding	120	Stewed apricots with raisins	100
			Bread, butter, coffee	260	Bread and butter	260
					Tea and milk	160
		520		980		1,170
Friday	Rolled oats and milk	200	Bean soup	250	Clam chowder	225
	Fresh meat hash	200	Boiled fresh salmon	150	Baked macaroni and cheese	200
	Soft boiled eggs	75	Hollandaise sauce	50	Asparagus salad	200
	Hot rolls and butter	260	Mashed potatoes	200	Dill pickles	
	Coffee		Escalloped tomatoes	100	Ginger bread	200
			Fresh apple pie, cheese	300	Bread and butter	260
			Bread, butter, coffee	260	Cocoa	250
		735		1,310		1,335
Saturday	Puffed wheat and milk	200	Pot roast of beef	200	Codfish cakes	200
	Broiled pork sausage	200	Brown gravy	50	Tomato sauce	50
	Creamed potatoes	200	Boiled potatoes	150	Spinach with egg	100
	Bread, butter, coffee	260	Creamed turnips	100	Bananas	100
			Bread custard with raisins	260	Bread, butter, tea	260
			Bread, butter, coffee	260		
		860		1,020		710
Sunday	Grapefruit	80	Asparagus soup	125	Shrimp salad	150
	Broiled ham	200	Roast chicken	250	Creamed potatoes	200
	Scrambled eggs	200	Mashed potatoes	200	American cheese	100
	Hot rolls and butter	260	Sage dressing	200	Sliced pineapple	100
	Coffee		Cranberry sauce	100	Raisin loaf cake	150
			Celery and olives	50	Bread and butter	260
			Vanilla ice cream	200	Cocoa	250
			Bread, butter, coffee	260		
		740		1,385		1,210

When the caloric values are totaled by days, allowing 600 calories each day for incidental articles of food used in cooking and flavoring, such as sugar and milk in the coffee and tea, flour and cornstarch used by the cooks as "thickening," etc., it will be found that the menu given will total as follows:

Monday	3, 735
Tuesday	3, 790
Wednesday	3, 270
Thursday	3, 270
Friday	3, 980
Saturday	3, 190
Sunday	3, 953
Average for 1 day	3, 598

In order to show the approximate amounts of the various nonstock items to order for a menu, the following list is suggested, based on a complement of 400 rations:

Amount:	*Delivery day*
600 pounds beef in sides (2 sides)	Monday.
300 pounds loins of beef	Monday.
300 pounds loins of pork	Saturday before.
250 pounds of fowl, dressed and drawn	Wednesday.
300 pounds of chicken, dressed and drawn	Saturday.
400 pounds of lamb, carcasses	Tuesday.
150 pounds salmon	Thursday.
10 gallons clams	Friday, a. m.
10 gallons oysters	Tuesday, a. m.
40 pounds codfish, shredded	Friday.
150 pounds pumpkins	Saturday before.
5 pounds mint	Tuesday.
200 pounds squash	Wednesday.
150 pounds turnips	Friday.
60 pounds cake	Saturday.

No estimates will be given for the remaining items of food on the menu, as they all are items which should be carried as stock items, and sufficient amounts of them should be in store at all times to meet ordinary demands.

The two sides of beef should be cut up and used as follows:

2 rounds 2 sirloin butts 2 chucks 2 shoulder clods	Use as pot roast for Saturday dinner.
2 loins	Use as beefsteaks for Tuesday dinner.
2 eight-rib cuts	Use as cold sliced meats for Tuesday supper.

The briskets, cross ribs, plates, navels, rumps, and flanks remaining can be used as hamburger steak on Monday. The two loins of beef trimmed out of the two sides may be added to the 300 pounds of loins ordered for Monday and cut up into steaks for the Tuesday dinner. The lamb carcasses should be cut up into legs, shoulders, racks, and loins. The legs and shoulders to be used as roast lamb for Wednesday and the loins and racks saved for issue to the special diets as lamb chops. There will be sufficient meats left over during the week to provide left-over meats from which to make the croquettes Wednesday and fresh-meat hash on Friday.

An important measure in the economical use of provisions is the proper cutting of meats. The description of meat cutting which follows is based on the instructions contained in the Navy training course for preparation for the rating of chief commissary steward.

MEAT CUTTING.—The FORE QUARTER OF BEEF consists of six major parts, namely: Prime ribs, chuck, plate, brisket, foreshank, and neck. Before dividing a fore quarter of beef the meat cutter removes the skirt steak by cutting at either end, pulling the steak toward him and keeping the knife close to the ribs as he cuts.

Dividing fore quarter.—First separate the fore quarter into two parts, one consisting of the prime ribs and chuck and the other consisting of the plate, brisket, shoulder clod, and shank. This cut is a long one, extending from the

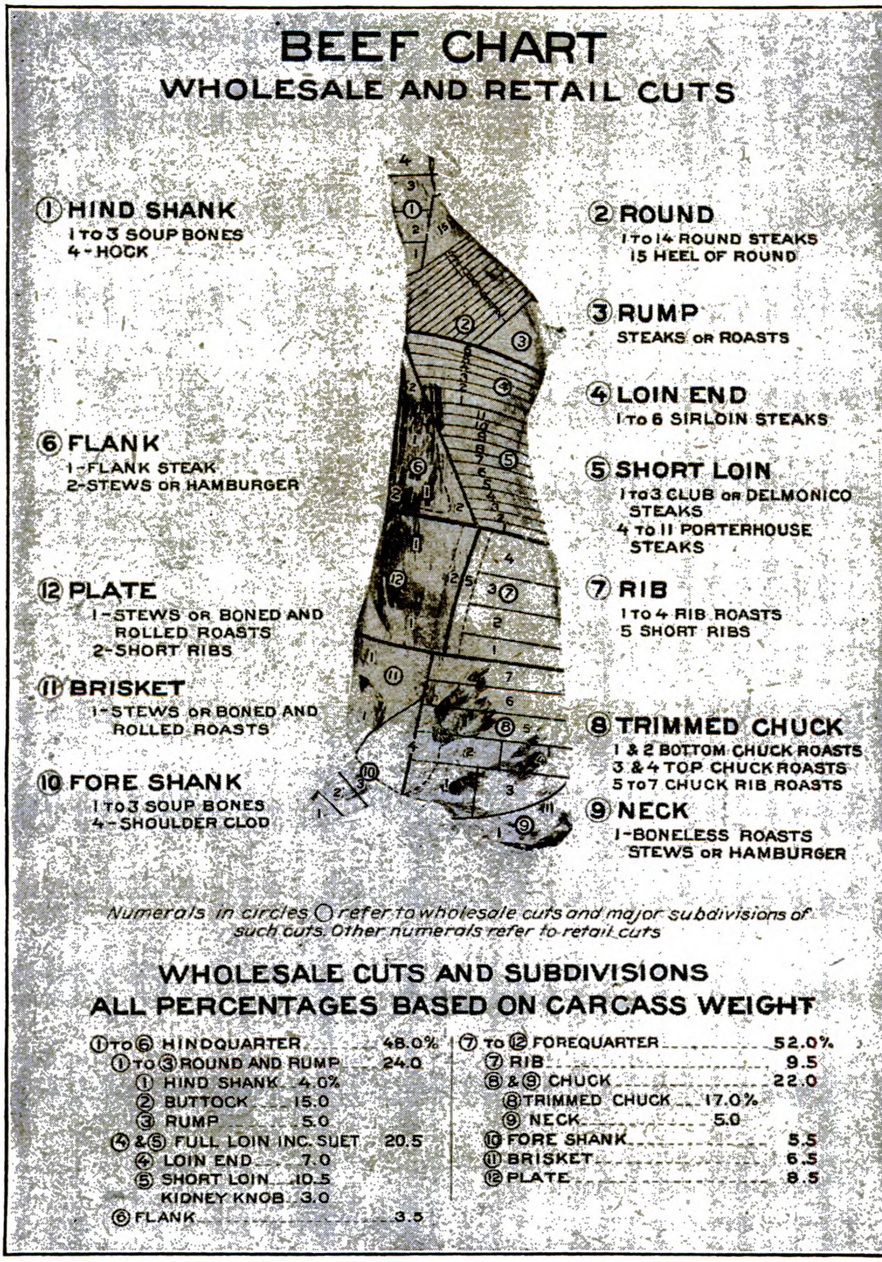

FIGURE 154.—Cuts of beef. (U. S. Department of Agriculture Department Circular 300, March 1924, plate I.)

first rib of the fore quarter through to the socket joint of the shoulder. First point off the proper distance on this rib about 10 inches from close under the chine or backbone. This gives the point where the cut must begin, and also insures sufficient length to the rib to make rolled prime rib roast. Before mak-

ing this long cut be sure to locate the top of the shoulder knuckle joint, which is easily done in chilled beef by using the shank for leverage. After this cut is completed the socket bone on the chuck side should not protrude beyond the cut surface, as more meat would be left on the brisket than is desired. Begin cutting at the point which has been marked off on the first rib and cut straight to a point where the meat of the ribs is thicker, and then angle from this point through the top of the shoulder knuckle joint, which completes the cut.

Separating shoulder clod and shank from brisket and plate.—In making this separation care should be exercised that this cut is so made as to leave on the clod all meat that properly belongs to it. Begin cutting where meat of the clod is flattened at the short-rib end of the brisket and cut to the depth of about 1 inch, where a guide is located. Then raise the shank, which affords a leverage that assists in striking the other guide under the shoulder. Next pull upward and cut directly under the bone, following the second guide closely to the first guide, and finally cut forward, separating the clod from the brisket.

Separating shank from shoulder clod, boning shank.—Place the shoulder clod on end upon the block with shank pointing upward. A piece of meat weighing about 1 pound which contains no sinews and lies on the front part of shank must be removed from the shank by following the natural separations between muscles, leaving it attached to the clod. Begin cutting at the top of the shin, following the separation between tissues and hard bone to the completion of this cut where the knife will touch the ends of bones which are peculiarly shaped at the joint and difficult to unjoint on account of heavy tendons.

Boning shoulder clod.—Begin cutting at the knuckle joint on the inside of the shoulder on "top of bone," following the line of the center of the bone downward to the other end. Remove from the bone, by a sort of skinning process, the soft tissue to which the muscles are attached. This entirely separates the bone from the meat.

Dividing plate from brisket.—Raise the plate and brisket on end with a full view of the ends of the ribs. Count off six ribs by tapping the ends with the back of the knife, then cut directly between sixth and seventh ribs from above downward, which will make it possible to cut through the bones of this part with the knife.

Boning plate and brisket.—First remove, by pulling, all the skinny tissues from the thoracic surface just over the breast bones. Then cut through tissue on the inside at the center of the ribs. Next insert the knife between the tissues and bone at the top of ribs, the meat cutter pulling the bones toward him and cutting at the same time, thus separating them from the meat. This operation removes the ribs. A small piece of meat which lies in the thoracic cavity near the lower end of ribs must be removed before boning the plate and brisket. The small bones of the plate and brisket can best be removed by inserting the knife close to the bones and by closely following their outline while cutting. When all hard fat and cartilaginous tissue has been removed from the muscles the boning of plate and brisket is complete.

Dividing ribs, chuck, and neck piece.—Set the major cut rib and major cut chuck upright on chine bone with ribs toward the meat cutter. Count off six ribs by tapping the ends with the back of the knife. Cut directly between the sixth and seventh ribs as counted, leaving an equal amount of meat on both ribs. Remove the neck piece from the chuck, cutting close to the socket bone of the shoulder. Do not cut so close as to leave bone exposed. There should be about an inch of muscle tissue covering the joint bone on the cut side. In removing the neck piece, be careful that chuck is squared. Then bone the neck piece.

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Boning prime ribs.—First remove the fat that lies exposed on or between ribs before this part is boned. Next saw off the chine bone along the line of the spinal canal. Raise the sawed end of the spine bones and cut all tissue attachments and remove the six spines together. Then remove the piece of "flax" or neck ligament just above the tip of each spine. Finally remove the ribs, being careful that no meat is left on the bones.

Dividing chuck into upper chuck and lower chuck.—Set up the chuck on the chine bone and divide it part way by forcing the hand downward in the guide, which is the natural separation between the heavy muscles of the chuck. Then cut directly under the shoulder blade from the prime rib end. Next cut through the remaining attached muscles, leaving an equal amount of meat on the upper and lower chuck.

Boning upper chuck.—Cut directly from the knuckle joint through the center of the meat on the shoulder blade on the inside of the exposed meat surface. Follow the shoulder bone closely, ascertaining that the meat which lies next to the bone is pulled from the knuckle joint downward along the shoulder blade. No meat will be left on the bone if this instruction is followed. When boning the other side, be careful at the point where the shoulder blade runs close to the skin muscles, as a soft tissue or cartilage is present at the top of this bone, where the knife is apt to cut through and render this part useless for roasting.

Boning lower chuck.—First remove the muscles which lie just beneath the vertebræ inside the thoracic cavity, for if cut through when boning this meat will be partially wasted. Then remove separately the three neck or cervical vertebræ of the chuck. The vertebræ bones must be closely followed while cutting so there will be few ragged edges. Next start from the other end of the chuck, removing the ribs and backbone.

The HIND QUARTER OF BEEF consists of four major parts, namely: Round, loin, flank, and shank. Before dividing it a hind quarter of beef is suspended from a beef hook and the first operation in cutting is the removal of the flank.

Dividing and boning hind quarter.—Start cutting just above the cod fat and cut downward to a point within a few inches of the hip bone. From this point cut straight downward for the entire distance, squaring off the short loin and leaving just enough meat on this end of the loin so that it can be rolled with the tenderloin included.

Preparing the flank.—The muscles which lie on the inside of the flank below the cod fat must be removed and used for steak or Hamburg. These form what is known as the inside flank, and all other meaty or muscular portions are known as the outside flank. All connective or skinny tissue and hard fat should be removed.

Removing the loin and top sirloin from the round.—Start at the top of knuckle joint on the round and cut through the hard piece of fat into the joint so that a finger can be put through for leverage. Follow the same on outside of the round directly downward to the socket joint at the lower end of the round. On the inside of the round, cut from the knuckle joint to the center of the round bone, which can best be detected by sounding with the point of the knife. Then cut downward along this bone to the socket joint. Next cut between the tissue and bone at the bottom of the knuckle joint, pulling the top sirloin downward and separating it from the round, and leaving it attached to the loin. Finally, cut from the socket joint through to a few inches below the point where the tail was removed, squaring off the loin. Use a saw to cut through the end of the socket bone and sacral vertebræ, which are called tail bones.

Removing top sirloin from loin.—Place the loin on the block and cut the top sirloin from the loin at point where the socket bone was removed, cutting at an

angle, so that when the top sirloin is placed base downward on block it will be set up straight. Remove the knuckle bone at end of the top sirloin.

Dividing short loin from sirloin, and boning these parts.—The first operation is to remove all the suet from the entire loin. Next remove the tenderloin; then cut the loin into two parts, separating the short loin from the sirloin by cutting just in front of the hip bone. To bone the short loin, first saw off chine bone, following the line of the spinal canal. Next insert the knife beneath the sawed end of T-bones and the tissues, and remove each bone separately by pulling while cutting. To bone the hip or sirloin, first remove the one T-bone on the short loin end; then insert the knife between the hip bone and tissues, cutting along the bone very carefully, as it is peculiarly shaped and difficult to follow.

Removing round from shank and large bone of the round.—Cut through tendon above the "horseshoe," which is a part of the round lying next to the shank, in which sinews or heavy tendons are found, and follow the guide downward. Cut a small hole in the horseshoe in which to insert the finger for leverage. This will make it possible, with the aid of a knife, to pull muscles, termed "horseshoe" from the shank. Next remove the meat from the long bone of the round by cutting downward, exercising care to cut beneath the tissues which are firmly attached to this bone and place the round on the block.

Subdividing and boning round.—The amount of meat termed "horseshoe" to be removed depends upon the quality of the carcass being cut. If it is of a good corn-fed steer very little "horseshoe" should be removed, but if it is a western or Texas carcass, sufficient "horseshoe" should be removed so that no tendinous and sinewy portions are left on the round. Place the meat on the block and remove more of the upper part of the round than of the lower part when removing "horseshoe" but cutting from the posterior side of the round forward at an angle to where the knuckle joint was removed. Next, remove fat and the piece of meat exposed on the aitchbone; then insert knife between the aitchbone and the muscle tissues and follow the outline of the bone closely, removing this bone and the tail of the rump in this operation. Always sew the rump in with the round.

Boning shank on block.—Begin cutting at the top of the bone on either side, cutting beneath tendon and tissue, and follow the seams downward. This will enable the cutter to remove all the meat from the bone in one piece.

The foregoing operations result in a division of beef as follows: Boned meat; suet; and bones.

Boned meat should be used as follows:

Roasts	Steaks	Boiled	Corned	Stew
Prime rib. Loin. Round. Rump. Chuck. Shoulder. Clod. Brisket.	Loin. Round. Prime rib. Rump. Clod. Chuck. Shoulder.	Shoulder. Brisket. Plate. Flank. Shank. Neck.	Brisket. Plate. Flank. Rump. Shoulder.	Brisket. Plate. Flank. Neck. Shank.

Boned meat for roasts should be rolled and tied.

For hash, croquettes, salads, hamburger, steak, etc., use the same cuts that would be used for stews or boiled beef. Of course, any parts of the carcass may be used for these purposes, if necessary, but the foregoing table should be followed, as it provides for the most economical use of the entire carcass.

All lean meat trimmings should be utilized for chopped beef and none wasted. Do not use an excessive amount of fat in chopped beef or Hamburg steak.

Tainted meat must not be used for any purpose. In cutting steaks always use the hind quarters if available; never the fore quarters.

Suet will be considered as including that fat which was removed during the dividing and boning, previously indicated. It includes the loin, pelvic, and cod fat. Kidney fats will be handled with other fats. All fats should be saved for grease and soap making. Be careful of this material; it is a money saver.

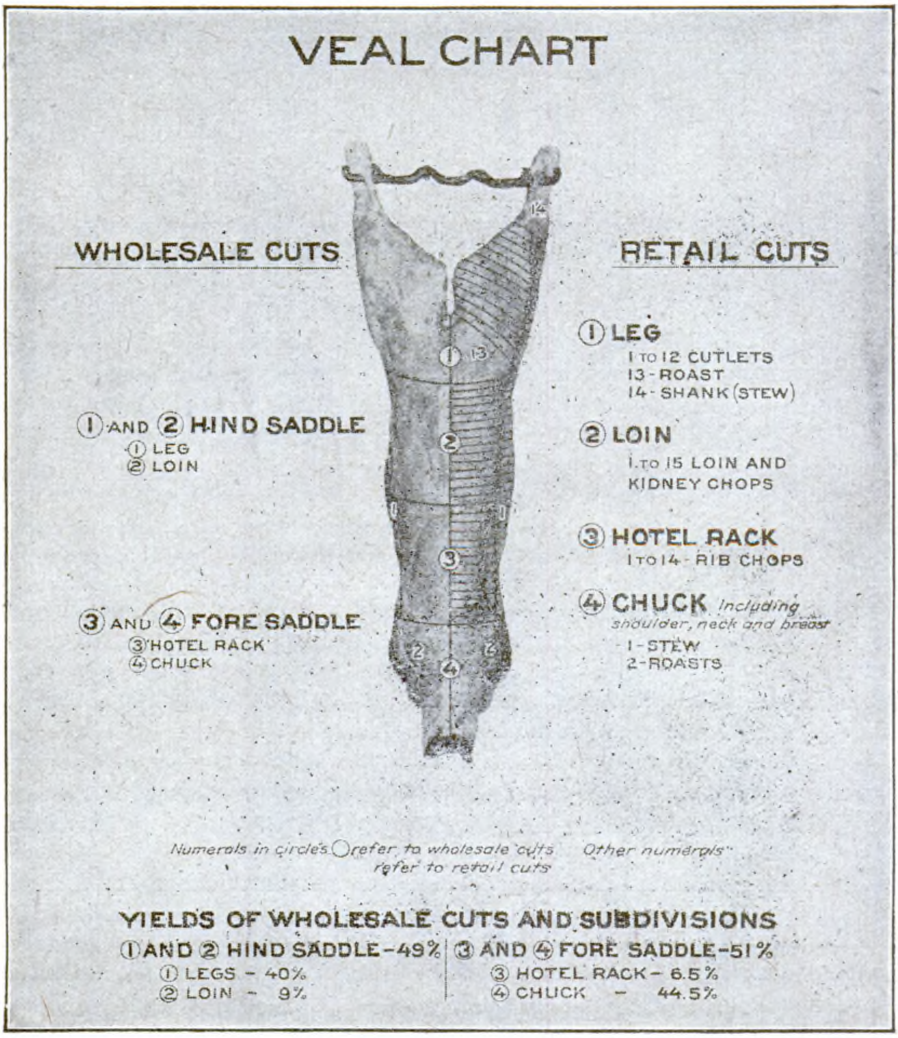

FIGURE 155.—Cuts of veal. (U. S. Department of Agriculture Department Circular 300, March 1924, plate II.)

BONES make material for the stock pot. Proper attention to the directions for cutting and boning will result in clean bones. There will, however, be particles of meat remaining on some bones, the quantity depending on the thoroughness with which directions for boning are carried out. All this material should go into the stock pot, keeping it in the chill room until needed if necessary.

VEAL.—In general, the directions given for dividing the major cuts of beef can be applied to veal. The amount of veal allowed is limited to 5 per cent of

the total fresh meat used plus any part of the 5 per cent formerly allotted to mutton which is not used in other fresh meats. This limits the use of veal to once or twice a week.

If cutlets or steaks are used, the hind quarters should be boned and sliced in pieces of about 6 ounces. When necessary, in order to obtain enough meat

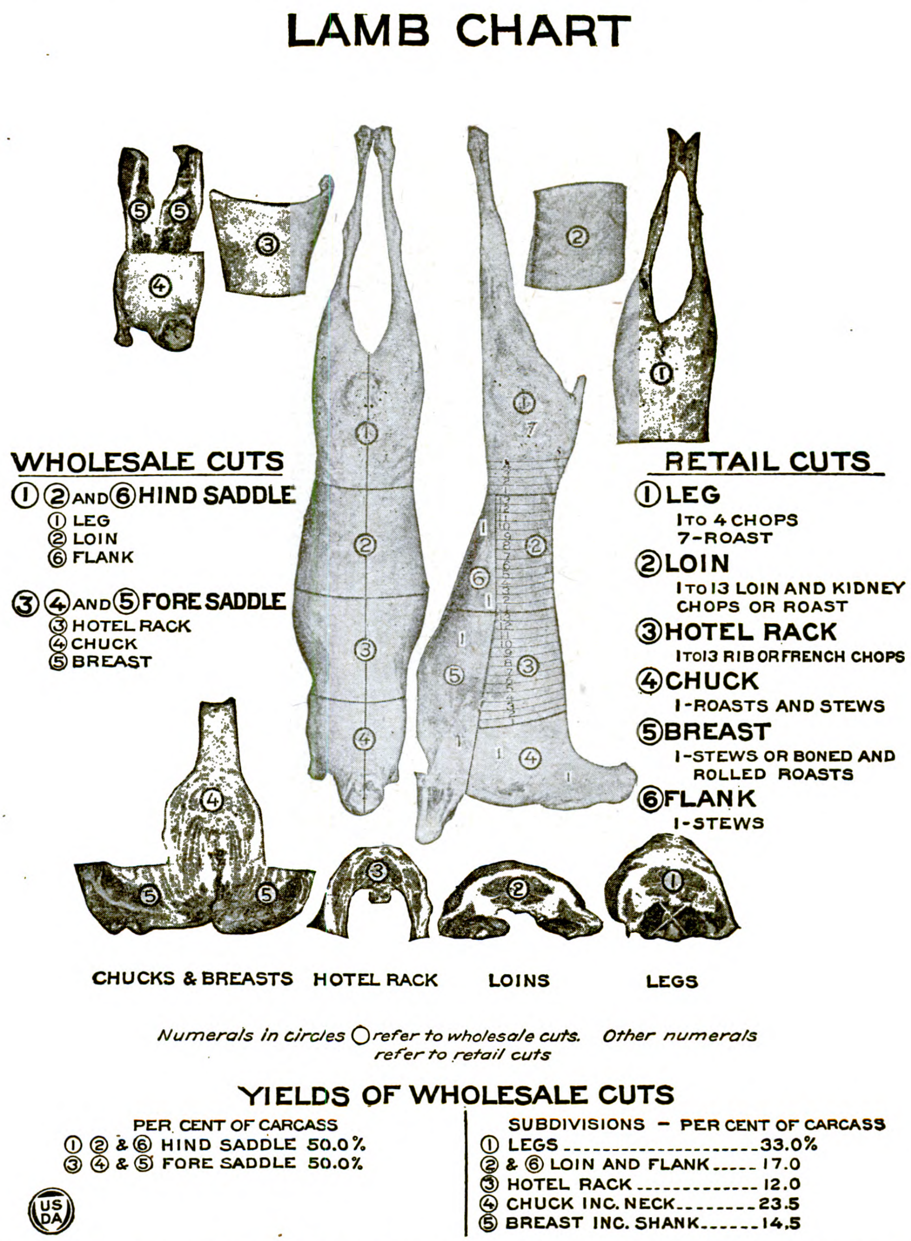

FIGURE 156.—Cuts of lamb. (U. S. Department of Agriculture Department Circular 300, March 1924, plate III.)

for a meal, ribs and chuck may be used from the fore quarter, but the menu is generally arranged so that the less desirable cuts can be put aside and run as a stew or fricassee. Boning is not resorted to in veal roasts as in cutlets and steaks. The beef cuts that are rolled for roasts are heavier than the cor-

responding cuts in the veal, which are not of sufficient thickness for rolling.

Veal, being younger and more delicate than beef, requires less time in defrosting and more care in handling.

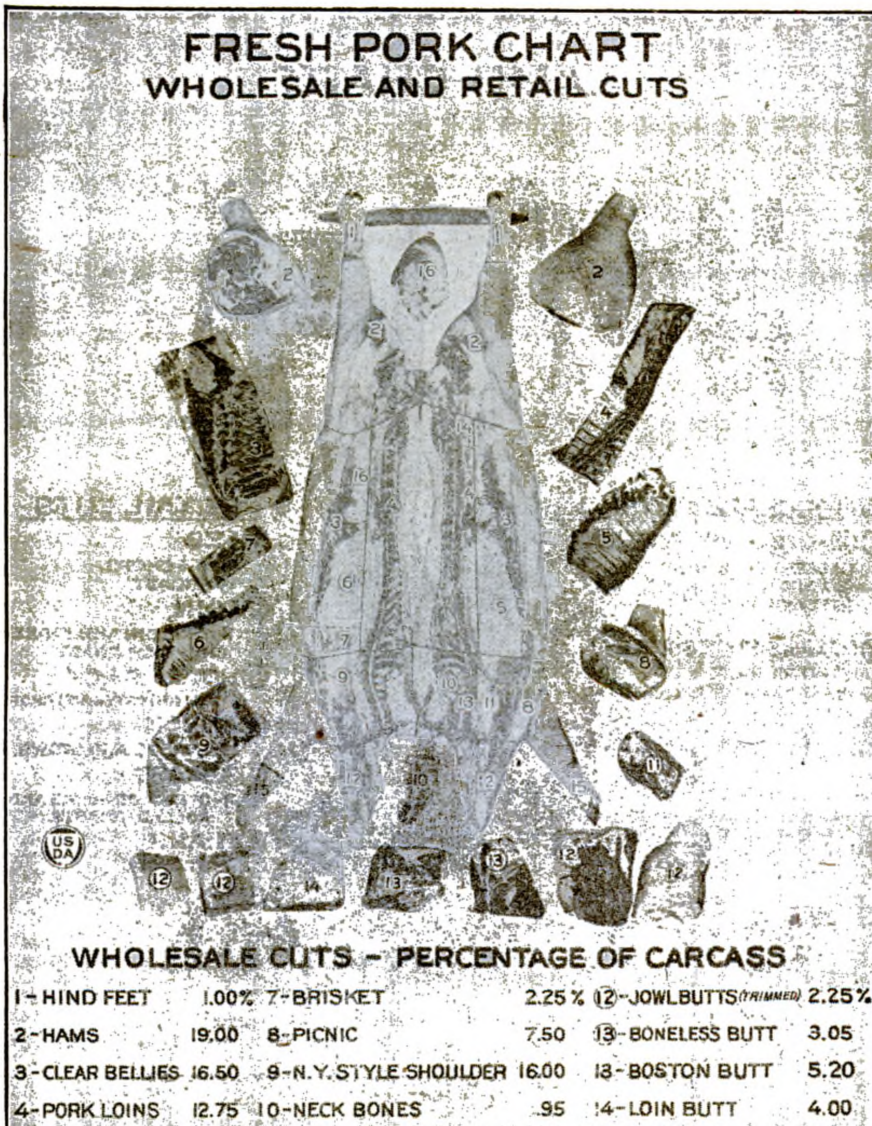

FIGURE 157.—Cuts of pork. (U. S. Department of Agriculture Department Circular 300, March 1924, plate IV.)

PORK CUTS.—Hog cuts for regular diets are confined to loins, smoked hams, and smoked bacon. The percentage of pork (10 to 15 per cent) allowed under fresh meat percentages (loins) will permit running this item about twice a week. Ham and bacon are usually high in price and their use will be governed both by variety desired and cost at time used.

CHICKEN, FOWL, AND TURKEY.—An understanding of the fundamental principles underlying the preparation of fowl for cooking and of cutting after roasting is necessary in order to serve it attractively and economically.

When these items of the ration are bought frozen, they are required to be dressed—that is, the feathers only are to be removed. When they are delivered fresh chilled, they are either dressed or dressed and drawn. "Dressed and drawn" requires removal of feathers, heads, and feet, as commercially trimmed in the locality where bought and with all entrails, except giblets, removed. Gizzard shall be clean and the gall bladder removed from the liver.

In handling fowl, singeing is necessary to remove down and hairs. Excessive pin feathers should be removed with a sharp-pointed knife. While the removal of tendons is desirable, it is not considered practicable for larger messes. To remove the entrails, make an incision through the skin below the breastbone just large enough to admit the hand. The gizzard, heart, and liver make up the giblets. Be careful in removing liver that the gall bladder, lying on the right under surface of the liver, is not broken. A little of the bile contained in the gall bladder will give a bitter taste to any of the flesh it touches. Be sure that the lungs and kidneys are removed. Remove the windpipe, crop, and oil bag. Wash by running water through the bird; do not soak it in water. Wipe inside and outside, being careful to see that everything has been removed.

In cutting a bird after cooking, place a fork firmly across breastbone, one prong on each side, and cut through the top of the shoulder, close to the neck down through the wing joint. A slight sweep of the knife removes the wing. Next, remove the leg and thigh by placing the knife between the breast and thigh, cutting downward to the joint next the body, bending the leg over and cutting off at the joint. Then divide the leg at the second joint, making two pieces, one the leg and the other the thigh. Next, remove the breast by cutting in a straight line with a heavy chopping knife from the point where the neck and back of bird come together to the end of the breastbone which is half way between the point of the breastbone and the tail. Split this cut into two rations. Divide the remainder of carcass by removing the first third of the back. Serve the remainder and retain the first third for seconds or stock.

When birds are large, it will be possible to slice breast meat from each side of the breast after removing wings and legs instead of serving each side of breast as a single ration as is done when birds are small.

Section 4.—DEATHS AND MEDICOLEGAL MATTERS

Silence.

The first rule of conduct for the hospital corpsman is to maintain a close guard upon his words and his actions. If he thinks twice before he speaks and then speaks not at all, he often will have cause to congratulate himself upon his good judgment.

Sad experience teaches this lesson in due course of time, or else the individual will find himself no longer connected with medical activities. The young man just entering upon a career in the Hospital Corps should try to acquire the habit as soon as possible. Moreover, the old saying that actions speak louder than words must not be forgotten. Information can be imparted intentionally or unintentionally by an appearance of excitement or a shrug of the shoulders as clearly as by voice.

This does not mean that matters are not to be discussed with persons who should know them, but it does mean that idle gossip is to be avoided. The

senior hospital corpsman and the medical officer are entitled to a knowledge of everything pertaining to the medical department that comes to the attention of the junior hospital corpsman, and all problems should be taken to them. Whether the information should go farther is a matter to be left to the judgment of the medical officer. The hospital corpsman acting alone is responsible to the person in charge.

The very foundation of a successful medical department is based upon confidence. Those who care for the sick and injured often have glimpses into the innermost thoughts and habits of patients that are denied to others, and it is only under such conditions that they can be properly ministered unto. A patient should know that he can confide in those caring for him, feeling that what he says or does will reach only those who are to help him. The minute that he thinks that anyone has abused his confidence the opportunity to aid him has been lost and the medical department has been placed under a cloud.

Hospital corpsmen also must be close-mouthed about other things than patients. Extend the habit to cover all the activities of the medical department. This is not for the reason that they are so secret, but because the person to whom one talks probably will not understand fully. He has not been trained medically and is not qualified to pass judgment, and has merely been provided with something upon which the imagination can work, and there is no telling where the incident will end. This applies not only to sanitary measures or ordinary occurrences, but particularly to accidents occurring in the sick-bay or operating room, to deaths from other than natural causes, etc. The medical officer bears the responsibility and it is for him to handle the situation.

The prohibition against talkativeness is to be emphasized especially in connection with this section. The hospital corpsman, by reason of his duties, comes intimately in contact with situations that afford rich material for gossip. Operations, deaths, autopsies—all, in time, may become largely matters of routine to him, but to others, however, they are unusual, and their details serve to gratify a morbid curiosity. The talkative hospital corpsman is always certain of a large and attentive audience, but not necessarily one of the highest order of intelligence. His story soon becomes entirely distorted as it is passed along. But the matter does not end there. He has betrayed a confidence and loses in large measure the respect of his fellows. Certainly they will not entrust him with their own troubles. The distortion of his tale may bring his department into disrepute. His value as a witness is lessened, for he may have said something in his enthusiasm as a story-teller that he would not feel justified in repeating under oath. He may have handicapped the investigation of some criminal act and thereby caused much inconvenience to the course of justice. And, last but not least, he may have made public something that, for the good of the service, should have been kept quiet.

So, both by words and bearing, a hospital corpsman must always strive to create confidence in the efficiency of the medical department. He should make others feel that there they will find competent treatment for their ills and solution of their sanitary problems; he should make them feel that he is incommunicative, not because he is unsociable, but for the reason that he minds his own business. No matter whether things are going right or wrong, a hospital corpsman should be calm, close-lipped, cheerful, and efficient. In other words, he should live up to the best traditions of the Hospital Corps.

Property.

The duties of the hospital corpsman often make him responsible for the property of others, and he will save himself and others much trouble by being very

careful. Few things cause as much worry and ill-feeling as an accusation by a patient or next of kin that some possession has been lost or stolen.

The original inventory on the hospital ticket (N. M. S. Form G) is very important, as it is the very basis of the transaction, and also because the patient may not see all of his property again for days or months or, perhaps, never. And, when he does take charge of them again, there must be no question as to whether the list is correct. So prepare it carefully, and actually see every item that is entered. Do not simply ask the patient what he has and put down what he says.

The patient usually is able to assist with the inventory, but occasionally he cannot do so because he is too ill or is insane. Precautions then must be doubled and there should be a witness to the inventory.

In the ward the patient often keeps certain valuables with him, such as a watch, jewelry, small change, etc. He should be advised to place them in safe-keeping, but usually does not do so. The habit of having a good idea of what is in a patient's possession is an excellent one to develop, for he may claim that something is missing, or he may become unconscious, or he may die. Then one is in a position to speak authoritatively as to whether everything is on hand that should be. (*See* par. 1762 (c)(7), Manual of the Medical Department, U. S. Navy, 1939.)

Often there is occasion to take charge of personal property, including valuables. This occurs upon death, or when a corpse is found, or when a patient for some reason can no longer guard his property. Ordinarily it should be done immediately, for valuables have a curious habit of soon disappearing. Do not wait an hour or so, but see that the property is placed as soon as possible under the care of the proper person. (*See* Manual of the Medical Department, U. S. Navy, 1939.)

Dispensing.

Matters of life and death are always under the hand of the hospital corpsman. This will be novel at first, but soon becomes familiar and tends to be mere routine, and the hospital corpsman must closely guard himself against the development of such an attitude. He is surrounded by death-dealing agents and uses them constantly, and the mistake that results in death or serious illness is not merely a sad occurrence, it makes him criminally responsible.

Every endeavor is made to supply all reasonable means of avoiding mistakes in the dispensing of drugs and the use of poisons. The regulations specify that the dangerous ones shall be placed in special bottles or kept under lock and key so that there may be no mistake. The poison bottle can be recognized easily in the light or in the dark. Failure to detect the poison bottle can be due only to gross carelessness.

Hold drugs and chemicals in deep respect, and cultivate at the outset the habits of care and precision. Be sure to be wide-awake when using them. Inspect the container, read the label, and be certain that it is the one specified by the prescription or by instructions. Settle any doubt by inquiry of the proper person. Label the containers promptly, and never think that the nature of the contents can be guessed when there is no label. *Never do any guessing.*

One of the greatest sources of trouble is the care of alcohol and narcotics. It is in their care and use that hospital corpsmen are particularly liable to the penalties of the law. The Manual of the Medical Department, U. S. Navy, 1939, in paragraphs 241, 736, 738, 1621, 1640, and 1672, discusses this subject, and the hospital corpsman must be thoroughly familiar with it. The very number of references indicates its importance. Article 1145, U. S. Navy Regulations also refers to it.

The insane.

Another situation, in which the hospital corpsman shoulders great responsibility and is very liable to come in contact with the law, is in the care of the insane. The very nature of his calling, naturally, will insure the best of care for the patient. But the problem goes deeper. It must be realized that an insane person is not responsible for his acts. He is a sick man, and does not think in all things in the same manner as those who are well. It is the duty of those caring for the insane to protect others who may come in contact with him, and also to guard him against himself.

Usually there is some person who has the responsibility for the welfare of the patient, and the instructions for his care will be definite and complete. But it is the duty of hospital corpsmen to use their common sense to the utmost. The person who is mentally unbalanced is extremely likely to injure himself seriously. Keep him under constant observation. Remove articles that are dangerous. Do not take any chances.

A hospital corpsman may have to guard an insane patient while traveling, or while he takes exercise on the deck of a ship, or in the grounds of an institution. Then one must be trebly careful for he may attack others, or try to escape, or attempt to commit suicide. It will happen unexpectedly and most suddenly, and he may avail himself successfully of some opportunity that failed to be considered or did not appear to be of importance. Remember that his condition may lead him to think or reason in a different manner than a normal person.

The best procedure is to cultivate the friendship and respect of the patient. How to do so is a problem in each case, but usually it can be done, and success in handling him will depend upon the ability with which this is done. And never forget that he is a sick man; he may make a nuisance of himself or attack his attendant, but he is not really responsible. It is a hospital corpsman's duty to control him, but it must be done by as gentle means as possible and without losing one's temper.

Dying declarations.

A hospital corpsman may happen sometime to be the one to whom a person at death's door makes a statement of importance; that is, a dying declaration, or ante-mortem statement. It may have to do with matters of money, property, or some criminal incident. Under any circumstances it is an expression of the thoughts and desires of a dying person. In it may lie the clue to the solution of some problem of crime. Therefore exercise every care to understand it correctly and fully.

To have full weight in law, however, and to be admissible as evidence before a court, the dying declaration must be made and recorded under certain definite conditions. Real responsibilities are assumed when circumstances compel one to receive such statements. And it is a duty to know how to insure that they be of legal value, and to make them so.

The person making the statement must be convinced that his death is soon to occur—he must have no expectation or hope of recovery. The person receiving the statement must assure himself that this is his attitude, and also, to the best of his ability, as to whether his mind is clear and rational. Then explain to him the importance of the statement he is about to make.

The statement must be voluntary; that is, not forced. Write it in his own words as he makes it, and be very careful not to include anything he does not say. Never put down what it may seem he should have said. If it can be done, have the person swear to his words before proper authority.

A declaration made thus will be of value in the eyes of the law, but do not hesitate to take any such declaration under any circumstances. Take it in writing, and remember which of these conditions has or has not been fulfilled.

Signs of death.

All are familiar with the tales of persons being buried alive. Such occurrences are rare, and the responsibility probably would never fall upon a hospital corpsman. The occasion may arise, however, when timely measures would save life that wrongly was supposed to be extinct. The proper equipment of the hospital corpsman should, then, include a working knowledge of how to recognize death. He then will be in a position to apply first-aid treatment and possibly save a life that would have been lost had he erroneously considered the person to be dead, and done nothing until the arrival of others.

The decision as to whether the person is dead ordinarily is made by a medical officer. It is only when a hospital corpsman is acting alone that he will be obliged to make it.

Death is considered to be present when the heart no longer beats and when respiration has ceased for more than 20 minutes. Both conditions must be present, and their proof is not always as simple as one might think. Do not rely upon any single test, but consider the results of all. No one test is conclusive.

Test for the heart's action by feeling for the pulse, and by feeling and listening over the heart. A stethoscope should be used for listening. If no pulse or heart beat is heard or felt, further evidence may be afforded by holding the hand, with the fingers extended and close together, against a bright light, and comparing the result with one's own hand. After death the redness that can be seen in a living hand is usually absent, the hand in question looking dull or opaque. Tie a cord or wrap a rubber band tightly about a finger near where it joins the hand; if the blood is circulating the finger will become swollen and bluish within a few minutes; no change is found when death is present. But remember that, if the cord is too tight, the blood going into the finger through the arteries may be stopped as well as that flowing out through the veins. Swelling and bluish color is secured when the pressure is just enough to stop the return venous flow but not sufficient to prevent the arterial.

Test the respiration by watching the chest for movement and by listening over the windpipe (trachea) in the neck, preferably using a stethoscope. Examine for at least 20 minutes. Have a good illumination, and it will be found that a cross light (one that throws some shadows) is best. A further test is made by holding a very cold mirror before the mouth and nose; moisture will collect if there is breathing.

The preceding examination is usually sufficient, and covers the early signs of death. The more important of the later signs are:

1. Changes in the cornea of the eye.
2. Cooling of the body.
3. Pallor of the body.
4. Rigor mortis.
5. Cadaveric lividity (suggillation).
6. Putrefaction, saponification, or mummification.

The corneal changes consist of loss of sensation, loss of transparency, and wrinkling. To be of real use, one must know the condition of the cornea before death.

The temperature of the body must be judged by the use of a thermometer placed in the rectum. Do not rely upon the touch of the hand. Occasionally,

the temperature rises for a time after death, but cooling soon begins, and its rate and extent will depend upon many things. It usually will be about 4° F. per hour for the first 3 hours, 3° per hour for the next 6 hours, and then rather more than 1° per hour.

A corpse usually has a peculiar ashy color that is suggestive but not conclusive as regards death.

Rigor mortis is a stiffening of the muscles and results in rigidity of the body. It usually appears within 2 to 8 hours after death and lasts from 16 to 24 hours, but both onset and duration are subject to wide variations. It extends commonly from the eyes gradually down over the body, and disappears in the same order. The muscular spasm and rigidity that occurs in some cases of poisoning may resemble it.

By cadaveric lividity is meant the purplish or reddish-violet colored spots that appear in about 12 hours after death, and are due to the settling of the blood into the parts of the body that are lowest as it lies. These spots often are mistaken for bruises. Upon cutting, however, bruises will show considerable blood or even a clot, while the spots under consideration will not do so. They are positive proof of death.

Putrefaction, saponification, and mummification are, of course, absolute proof of death. Putrefaction (rotting) does not appear until rigor mortis has gone, and its onset usually occurs within a few hours to many days, depending upon the circumstances. Saponification and mummification are late incidents, and unusual. They preserve the body for long periods of time. Saponification means the conversion of the corpse into a fatty or waxy substance called *adipocere*. Mummification consists of the complete drying of the body.

Care of the dead.

The hospital corpsman should familiarize himself with the general procedure in cases of death, studying particularly chapter 19 of the Manual of the Medical Department, U. S. Navy, 1939.

Frequently one will be obliged to take charge of the body of a person who has just died. The first duty in such a case is to consider the living. Remove all traces of death as soon as possible. A death is very depressing to other patients, and one should try to avoid having it occur in their presence, as in a ward. The medical officer usually will order a patient on the eve of death transferred to a private room, if possible. When this cannot be done, the bed should be well screened.

The imaginative or morbid patient who realizes that a death has occurred in his vicinity will imagine himself as possibly dying and his body being treated as he sees this one treated. Hospital corpsmen should bear themselves well in hand, and be quiet, calm, orderly, and, above all, respectful. Make others do the same. There is no place at such a scene for noise or tomfoolery. Let the dead be respected. And this should apply not only for the moment but at all times until and after the remains have been removed from the institution.

When the patient has been pronounced dead, take charge of the remains and, possibly, the personal property, if no person in authority is available immediately. Gather the property together, store it safely for the moment, and make a list of it and transfer it as soon as possible to the proper person. (*See* par. 1672 (c) (7), Manual of the Medical Department, U. S. Navy, 1939.)

Certain things (given later in detail) must be done for the corpse, but, unless it lies in a private room, these are accomplished best in the morgue. Before the body is removed from the bed, fasten securely upon it a tag that bears the full name and rating of the person, the ward where death occurred, and the date and exact time of same. Removable teeth must be sent with the body.

If death has been due to a contagious or infectious disease, the body must be wrapped in a sheet wet with 5 per cent phenol (the official embalming fluid is preferable, if it is available) before being transferred. When the body has been removed, disposition is to be made of the bedding, and the bed, bedsprings, bedside table, etc., need attention. This varies with the customs of the institution and with instructions, but the use of soap and hot water and a disinfectant is essential. It is a good general routine, however, to remove all bedding, including the mattress, if the death occurred in a ward. No patient likes to believe that he may be obliged to use such a mattress. Disinfect the bedding, to still wagging tongues if for no more important reason, and wipe the furniture with some suitable disinfectant.

The body must be "laid out" as soon as possible. Rigor mortis may begin quickly, and its presence renders proper care difficult. But early attention is desirable for other reasons as well—prevention of discharges and soiling from the anus, the penis, the vagina, the mouth, and the nose, or other openings. Pack these openings tightly with cotton. A little salt in the cotton may be of help. Discharge from the penis is best prevented by tying a length of bandage tightly about it. The packing for the mouth should go well back into the throat. Insert any artificial teeth. Place the body on its back, and straighten the limbs, holding the knees together with a loose, broad bandage. Place the hands across the chest or abdomen, and secure the wrists together loosely with a broad bandage. The head should be slightly elevated by means of a pad or block. The mouth must be closed. It is better to hold the jaw in position by means of a support, such as a folded towel, beneath the chin, rather than use a bandage. The eyes must be closed. If they do not remain so, place wet pledgets of cotton upon the lids, or, if necessary, insert a very small piece of dampened cotton beneath the upper lid. Finally, cover the body with a clean sheet, or, if necessary, rewrap it in the sheet that has been wet with phenol.

Deaths from unnatural causes.

The first rule of conduct, when one finds the remains of a person who apparently has met his death from violence or other unnatural causes, is to avoid any disturbance of the body or of objects in the vicinity. Make certain that the person really is dead, and then see to it that nothing is disturbed until those in authority so direct. This applies to others as well as to the hospital corpsman, but, as he probably will be in charge, his will be the responsibility.

Avoid unnecessary handling of objects about the corpse, especially such as may bear finger-prints.

The only reasonable excuse for disturbing anything will be to ascertain whether or not the person is dead. And, before doing so, a clear mental picture of the condition and position of the body before disturbance must be formed. Meanwhile, be sure to notify the medical officer or other person in authority. If no messenger is available and the remains must be left alone, endeavor to prevent possible tampering by others, as by locking the room. Return and reassume charge as soon as possible.

A hospital corpsman probably will arrive at the scene early, and he must try to make himself a useful witness. Imprint clearly upon the memory the position and condition of the body and of objects in its vicinity. This requires that one's common sense be used to the utmost. Prepare a private record of the results of the inspection at the earliest possible moment. Memory is treacherous, and later one may be very thankful for such notes.

Previous remarks relative to valuables apply here also. Make an inventory of those that are visible so that it can be referred to if the question arises later as to whether something has been lost or stolen.

Habits of silence will be of particular importance in connection with unnatural deaths. Beyond its value in general, as already discussed, here one must anticipate a probable call to the witness stand. One's knowledge should be clear in the memory, as well as clearly stated in the notes. If the matter is discussed with unauthorized persons, all sorts of suggestions and comments will be heard, and, before long, one's own knowledge may become so contaminated that one doubts whether he really saw what he thought he did. And unconsciously the opinions of others may be permitted to replace one's own. The court is not interested in this hearsay evidence—the thoughts of other persons. It desires what one knows of his own knowledge, and therefore strive to preserve that intact and clear-cut.

Identification of the dead.

This problem usually will fall to the lot of persons other than the hospital corpsman. Still, he may find himself so situated that he must give an opinion, and he should be familiar with the means that may be employed.

The records kept in the naval service are usually very complete as to the physical characteristics of each individual. There are the health record, the service record, and the finger-prints. The portion of the health record that is devoted to the teeth is of great importance.

There is also the identification tag. But even the finding of such a tag with the body must not be considered conclusive evidence of identity. The characteristics listed in the before-mentioned records of the individual specified by the tag must check with those of the corpse before identification can be considered as established. A finger-print also must be made, and compared with that on the tag.

The procedure to be followed, then, involves a careful examination of the body for the points recorded concerning some missing person. Not only must marks, moles, and scars be considered but also external measurements, color of hair and of eyes, deformities, etc. It is especially important to compare the teeth closely with the description in the dental abstract.

It is surprising how obscure scars, moles, freckles, and birthmarks can become after death, even when decomposition has not occurred. The latter, of course, adds to the difficulty. So, the search must be very carefully made, and it is all-important to have a good light. It is for this reason that the dental record is of such able assistance. The peculiarities of the teeth are very reliable and permanent.

It is the finger-prints, however, which will settle any doubt. The epidermis is very resistant to decomposition. As long as it is present, it will be rare that serviceable prints cannot be secured if proper care is exercised. Even when the skin is shriveled, good results usually can be obtained by carefully following the directions given in chapter 11, Manual of the Medical Department, U. S. Navy, 1939 or subsequent circular letters that may come from the Bureau of Medicine and Surgery.

Occasionally, the remains consist only of a number of bones. The teeth will help in such a case. Otherwise, the identification will be beyond the ability of the hospital corpsman. If other aid cannot be secured, his problem will be to determine how many bodies are represented by the bones. This is not so difficult if many bones are present. Look for duplicate bones, but remember that there are two sides to the body.

Post-mortem examinations.

After death, a body often is opened for examination, the proceeding being known as a post-mortem examination (also called necrospy, necroscopy, or autopsy).

The duties of the hospital corpsman at such an examination are those of an assistant. It lies, however, within his power to make the task run smoothly, or to have it unsatisfactory. Great care of instruments in the operating room is exercised, but the same cannot be said of those in the morgue. The first duty is to have them in proper condition—cutting edges sharp, forceps that grasp, joints that are snug, etc.

A commendable attitude on the part of a hospital corpsman is to strive to fit himself to perform the autopsy with his own hands. This, of course, means close observation of others at work, and intensive application. Study anatomy, and also the sections on autopsies to be found in textbooks. In time one may attain the necessary proficiency, and will have benefited himself in knowledge and also in efficiency as a hospital corpsman. Moreover, the instruments in his care will receive proper attention because he will have had to use them.

It will be the hospital corpsman's duty to prepare the room, instruments, utensils, etc., and to care for them when the examination is finished. It probably will be his duty also to close the openings (incisions) that have been made in the corpse, and he may be directed to embalm and dress the body, under supervision. Just as in the operating room, no two medical officers will pursue precisely the same method, and one should ask beforehand for instructions as to doubtful details.

As regards the room where the examination is made, it should be neat, clean, and comfortable. Be sure that the lights are in good working order. A portable light will be found useful at times, as well as a flashlight. Regulate the heat, and also the ventilation. There is a great tendency to neglect these last-mentioned details, and the result is that often some of those present "catch cold." So, provide for the escape of odors, but do not do so at the expense of a proper warmth and freedom from drafts.

Have the water supply working properly. If there is piping for hot water, see to it that hot water is available. The plumbing needs care, and remember that the traps may retain fluids which will decompose and cause foul odors. It is well to flush them with saponated solution of cresol after each use of the room.

Check the scales occasionally to be certain that they weigh accurately.

Due economy should also be exercised in this work. Good hand towels, absorbent gauze, and absorbent cotton are expensive. They may be needed for certain purposes, but certainly never for cleaning or mopping about the room or about the corpse, for which old, surveyed linen is available. Sections of crash toweling also can be used to advantage for less filthy tasks.

Certain equipment, in addition to the furniture of the room, must be provided, and, if possible, it is preferable to have a locker for storage of the same rather than to attempt to secure it in a hurry just prior to the examination. At that time, one may not have much notice. The medical officer will indicate his special desires as regards equipment, and will advise if any unusual procedures are contemplated. The list following includes articles that should be available as a matter of routine for the examination itself. Cleaning gear for general use will be in addition.

Three rubber aprons.

Four gowns.

Rubber gloves for three persons. (Provide an extra pair for each person, and have them of the size and weight desired by those who will use them.)

Six hand towels. (For use at the sink by persons who may desire to cleanse their skin.)

Soap. (For the hands.)

Two sheets. (For the corpse.)

Cotton, absorbent. (To be used sparingly.)

Gauze, absorbent. (To be used sparingly.)

Bandages, gauze, assorted sizes.

Necroscopic case of the Supply Table of the Medical Department, U. S. Navy. (Be certain that each article is in good working order.)

Head block. (Used beneath the neck of the corpse to hold the head forward while removing the brain.)

Three sponges, about the size of a man's head. (These are very useful for mopping about the corpse. Great care, however, is necessary in order to keep them in sanitary condition. Cleanse them thoroughly with water after use, and store them in a large jar of 2 per cent formaldehyde.)

Twine. (A ball of same for use in tying during the post-mortem examination.)

Board, 1 inch thick by 18 inches square, and smooth. (For use in sectioning organs.)

Needles and thread. (For use in closing cuts in the corpse. These are selected according to the desires of the person doing the work.)

Trays, enameled. (For holding and local transportation of organs, etc.)

Three buckets, agate. (One for use at the drain of the table, one for rinsing sponges, and one for general utility.)

Memorandum pad and pencil. (For taking notes during the examination.)

Outfit for tissues or fluids that are to be saved for histological or bacteriological examination.

Outfit for material saved for chemical examination.

Outfit for disinfection of cuts, punctures, or abrasions occuring during the examination.

The corpse having been placed upon the table prior to the necropsy and covered with a sheet, clear the vicinity of idly curious spectators, and then make the necessary preparations. Have the equipment at hand, and regulate the details of heat, ventilation, water, etc.

Arrange the contents of the necroscopic case and the sponges upon a cloth-covered table where they will be convenient to the hand of the pathologist (the person who is performing the necropsy). The linen, trays, and other materials are placed upon another table where they can be easily reached. Place a bucket where it will catch the drainage from the table. When the time for the examination arrives, remove the sheet from the corpse, put on a rubber apron, gown, and gloves, and be prepared to assist as directed.

The skin of those working at a necropsy may be broken accidentally by needles, instruments, and otherwise. Such wounds may become infected and be very serious. The medical officer will prescribe the proper treatment, but one should have at hand some things for immediate disinfection, including a 200 cc bottle of tincture of iodine, wooden applicators, absorbent cotton, small pads of sterile gauze in muslin packages, and gauze bandages.

When the necropsy is finished, the openings that have been made must be closed and the corpse cleansed and dried. The closing is to be done neatly by means of needle and thread and a simple running stitch. The aim is to leave the body presentable, not only as a matter of pride, but also because it probably will be viewed later by friends and relatives. It would be a waste of time to try to give directions for this, as no two bodies will require the same treatment. It is a matter of common sense and experience, and the medical officer will advise in each case.

Sponge all cavities until dry. The viscera, such as the brain, lungs, heart, and those of the abdomen and pelvis usually have been removed and, unless local laws make it mandatory to do so, it is best not to return them to the body before closing. Instead fill the cavities with absorbent cotton soaked in embalming fluid or with a hardening compound as described in the section on Embalming. If important bones have been removed, pieces of wood can be wired in their place. When the skull has been opened to examine the brain, special care must be exercised to prevent the skullcap from slipping after the scalp has been sewed. This can be done by means of sutures (stitches) through

soft parts or drill-holes before closing the skin. Double-ended tacks are also useful for the purpose.[6] If the body is not embalmed or dressed immediately, cover with a clean sheet as at the start of the examination.

Embalming usually is done at about this stage, probably most satisfactorily before the openings have been closed. The remains then are prepared for burial by dressing and placing in the casket or coffin. Full directions for these procedures are given in the section on Embalming and in the Manual of the Medical Department, U. S. Navy, 1939, section 4, chapter 19. Circular letters concerning them also appear from time to time from the Bureau of Medicine and Surgery. Study the directions given in order to be able to follow them implicitly.

It cannot be emphasized too strongly that every care must be exercised to make the body presentable. Probably no other single thing, when not perfectly done, can occasion more distress to friends and relatives, and cause more trouble for those responsible. Friends and relatives are extremely critical, and one must spare no precautions that may prevent criticism. Use the razor upon those who have been accustomed to shaving as carefully as if shaving oneself. Wash the body with soap and water until clean. It is well to give the hair a shampoo. Clean and trim the nails. And a few toilet articles, such as a little talcum and something to make the hair lie smoothly, are of real help. Arrange the hair so as to hide any cuts that have been made in the scalp. Clothing and linen must be clean and neat, and should be arranged so as to hide features that may be distressing.

After the work in connection with the body is completed, the room and equipment must be cleaned and put in order. This is largely an ordinary cleaning procedure. The care of certain articles of equipment already has been specified. Instruments should be in perfect condition before storage, and covered with a thin coat of vaseline. If they are so left it avoids trouble in case they are needed in a hurry. If the post-mortem examination has been of a person dead from a contagious or infectious disease, the usual precautions listed elsewhere in this book must be observed—the room, contents, and oneself being treated or disinfected to prevent spread of the disease. An occasional fumigation of the morgue is a useful routine measure.

Mention has been made of an outfit for tissues or fluids that are to be saved for microscopical examination or for preservation of large specimens. For the latter purpose instructions will be given by the medical officer. Usually they are carried to the laboratory in trays, closely covered. Certain things should be kept on hand for specimens for microscopical examination, and by so doing much trouble will be saved because a decision to save something usually will be made on the spot and the incidentals will be wanted in a hurry.

It may be desired to secure some sample, usually fluid, under aseptic precautions, and therefore certain articles of the equipment must be stored in sterile condition. A free flame, such as that of a Bunsen burner, is of use under such circumstances. Between it and the tincture of iodine, that is on hand for wounds, there should be no difficulty in securing a suitable specimen.

The list of articles following usually will handle the situation. It is well, however, to consult the medical officer in charge of the laboratory on the subject, as he may have some other preference.

One test-tube rack.
Ten test tubes, sterile, and plugged with cotton.
Twenty slides, glass (clean, flamed, and protected from dirt).
One platinum loop, in a handle.
Twelve sterile swabs, two packages of six each. (Wooden applicators with a small amount of cotton wrapped around one end. Make a muslin-covered package and sterilize).

Syringes, all glass, 10 cc capacity, in sterile package. (One syringe with two large-bore needles in each package. The needles should contain their wires.)

Ten bottles, wide-mouthed of about 50 cc capacity, with corks.

One bottle, containing 1,000 cc of 10 per cent solution of formaldehyde. (Liquor formaldehydi). (For use in the bottles above for the preservation of small pieces of tissue.)

Pencil, wax. (For writing on glass.)

There are occasions also when it is necessary to preserve portions of the corpse for chemical examination, usually for poisons. This is practically always a legal matter and the procedure must be surrounded with every precaution. Either accidentally or intentionally, there may be tampering with the specimens; therefore every care must be exercised to have them reach the chemist in proper condition—nothing having been added to them or removed from them. Not only must the medical officer and the hospital corpsman be satisfied as to this, but they must be able to convince a jury, which can be accomplished only when all concerned can, upon their oath, testify that the necessary precautions have been observed.

It follows that the work must be protected by seals, and the seal should be one that cannot be imitated readily or that can be used only by those in authority. Unauthorized tampering with the specimens then would be known. One also must try to permit no opportunity for the same by means of the strictest safeguarding under lock and key.

A medical officer ordinarily will supervise the work in this connection. It is well, however, always to be prepared for an emergency. It often comes unexpectedly and the containers cannot be prepared at a moment's notice. Many precautions are necessary for this. So prepare the containers in advance and seal them effectively. Seal them in a package and keep them under lock and key.

The viscera that practically always are saved for chemical examination are the stomach and duodenum with their contents, the intestine, the liver, the kidneys, and the brain. Often, also, other organs, as well as the urine, are saved—in fact, any portion of the body may be saved for chemical examination. So one must have containers large enough to hold such material. There should be a bottle or jar for each organ to be saved, and the different organs should be placed in separate containers—not all together. The containers must be thoroughly washed with soap and water, treated with strong sulfuric acid, and finally, thoroughly rinsed with distilled water. When prepared, wrap each one separately in firm, stout paper and secure the paper with tape or stout twine passed over and around the jar several times and in all directions. Seal each package with wax at many points.

A reasonable outfit then will consist of the following:

Ten jars, wide-mouthed, preferably glass-stoppered, assorted sizes. (There should be no rubber or metal at the joints or elsewhere that could come in contact with the contents. Joints are closed with paraffin, after the specimens are in the jars.)

Five bottles, glass-stoppered, assorted sizes from 1,000 cc capacity down.

Five catheters, new, of assorted sizes. (These are to be thoroughly cleaned and stored in perfectly clean bottles. They are used for securing the urine or other fluids.)

Distilled water. (Secure a large bottle for the purpose from the laboratory the same day as the examination.)

Paraffin. (Several cakes.)

Rinse the containers with distilled water just before the material is placed in them. Then they are covered, the joints closed with a very liberal amount of paraffin, labeled, and immediately sealed as before. If they are to be kept for a time or shipped some distance the best practice is to keep them constantly at

as low a temperature as possible. If this cannot be done a liberal quantity of 95 per cent alcohol should be added to the contents and 500 cc of the same alcohol placed in a perfectly clean bottle and sent with them.

Make an inventory of the number and contents of each container. A copy of the inventory is sent along when a duly authorized person makes the shipment and a copy of the imprint of the seal should be included.

The matter of shipping specimens of medical interest is not as simple as one might think. The express companies and the postal authorities place many restrictions upon such packages, and one may get into trouble if he violates the regulations. Therefore before making such a shipment be sure that it is being done properly. Consult the local express company or postal authorities. Circular Letter X, Appendix D, Manual of the Medical Department, U. S. Navy, 1939, discusses the matter, and one should familiarize himself with its contents.

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CHAPTER XII

HOSPITAL CORPS TECHNICAL SPECIALTIES

Section 1.—AVIATION MEDICINE

Aviation first assumed military importance during the World War. Since the armistice the race for aeronautical supremacy on the part of almost every country has been continuous and unremitting. Considered in the light of present day military value, aviation is regarded as one of the most important military arms. The effort to constantly surpass in performance all preceding types of planes, led to great advancement in the modern types of aircraft. So great have been these advancements, that performance of the modern plane now tends in many ways to surpass the ability of the pilot at control. Planes now fly long hours in continuous sustained flights. Speeds have been tremendously advanced. Maneuverability has been whipped up until the pilot is seriously taxed in his effort to operate the advanced types of aircraft at their maximum capacity.

In the face of these facts it is being realized daily that the weakest link in the chain of aeronautical forces is the human element, the pilot. However efficient the plane may be, in the final analysis its safety in flight depends upon the physical and mental fitness of the pilot. Therefore, good pilots must be developed as well as good planes, and it is as necessary to safe-guard and care for the pilots as it is to service and repair the planes.

The selection of and the daily care of pilots has become a specialty of military medicine which is called "Aviation Medicine". It requires specially trained medical officers or flght surgeons, and the assistance of specially trained hospital corpsmen or aviation technicians. Assignments of hospital corpsmen for this special training are made after approval of requests for such training by the Bureau of Medicine and Surgery.

Although the primary goal of aviation medicine is the prevention of accidents, to increase the safety and efficiency of flying its field of activities has been roughly divided into two parts, namely: 1. The selection of flying personnel; and 2. The care of flying personnel. While the aviation technician may be of very

great assistance to the flight surgeon in both these fields of endeavor, he is particularly helpful in regard to the examination and selection of flying personnel.

Physical examinations.

Every applicant for flight training must first pass the flight physical examination and all pilots and aviators shall likewise take the annual physical examination for flying, not later than January of each year. (*See* paragraphs 1538 to 1544 inc., Section 23, Chapter 11, Manual of the Medical Department, U. S. Navy, 1939.)

The physical examination for flying is a rather long and considerably involved examination, which requires the use of special appliances, such as the phorometer, an instrument for measuring the strength of the external muscles of the eye, the Barany chair, for study of the reactions of the semicircular canals, and other apparatus not commonly used in the ordinary type of examination. The report of the examination is submitted on a special form, N. M. S.–Aviation No. 1, which contains the necessary printed instructions for guidance of those preparing the reports. It is in the use of this special apparatus and familiarity in the preparation of the various aviation forms that aviation technicians may be of very great assistance.

Generally speaking, the aviation technician should have a ready knowledge of the physical requirements for flying and a thorough familiarity with the contents of Section 23, Chapter 11, Manual of the Medical Department, U. S. Navy. He should have a working knowledge concerning the use of all the special appliances used in connection with the examination. He should be able to conduct a great portion of the measurable part of the physical examination, such as determination of visual acuity, angle of convergence, the Barany chair test, height, weight, chest measurement, and the taking of the Schneider Index. Ordinarily the flight surgeon is present, or conducts all phases of the physical examination, but a familiarity on the part of the technician concerning the details of the examination is of great assistance to the examiner. The technician is also expected to be familiar with the preparation of the special report of the examination, Form N. M. S.–Aviation No. 1, and also the preparation of Form N. M. S.–Aviation No. 3, Report of Crash.

Ordinarily upon reporting, each pilot or aviator is given a special filing jacket, in which all current reports of physical examination and other important data are filed. It is the duty of the aviation technician to look after the records and properly maintain the files pertaining to the physical and medical records of flying personnel.

Schneider Index.

The Schneider Index is the name of a special test to determine the circulatory efficiency of an individual. It is based upon the recording and assignment of numerical factors to the reclining and standing pulse rate and blood pressure, and the changes produced after a given exercise. (*See* Paragraph 1565 (f), Chapter 11, Manual of the Medical Department, U. S. Navy.) The test is easily and quickly given and indicates to a very practical degree the nature of an individual's vasomotor tone and control.

Normally, flying personnel whose Schneider Index falls below 7, should be temporarily disqualified for flying. Inasmuch as the test is so constantly used in examining and checking the physical efficiency of aviation personnel, all aviation technicians should be thoroughly familiar with this test and should develop a careful technique in its conduction. They should always avoid hurrying the examination or exciting the candidate. Such errors of technique lead to low scores, which do not represent the true physical picture.

Care of flying personnel.

In this sphere of aviation medicine a great deal could be stated. When one realizes that flying establishes a new environment, to which the pilot must become adjusted, one can begin to appreciate the many problems to be solved.

Generally speaking, flying personnel require a higher degree of physical perfection than is normally required of other Navy personnel. This is referred to as physical reserve. Especially is this required for the eyes and the circulatory system. Due to the effects of diminished oxygen at high altitudes, pilots who lack physical reserve or efficiency are readily affected at such altitudes. Their efficiency is lowered and frequently their flight may end disastrously.

It is because of these additional demands, that pilots should lead orderly lives and maintain a high state of physical efficiency at all times. The loss of sleep and rest, the excessive use of alcohol, and other forms of intemperance, tend to lower physical efficiency and should be avoided. Flying personnel operating in big-boat squadrons are often subjected to long fatiguing hours with poor tender facilities, and therefore inadequate provision for rest at night. They soon reach a virtual stage of weariness and near-exhaustion. Domestic troubles, loss of confidence in flying, recent crashes, all may serve to affect individuals. Frequently the worries may be mild at first, but as time progresses the pilots gradually develop a nervous anxiety state, which comes to seriously affect their flying. The terms staleness, or effort syndrome, or neurasthenia, are commonly used to describe such cases.

In caring for the flyer, all these conditions should be kept in mind. The pilot should be assisted past all such difficulties, and it is to such a task that the field of aviation medicine is in great part directed.

First aid.

In the pressure of aviation activities, both ashore and afloat, active measures should be taken to render first aid promptly in case of an accident. Crashes frequently occur over the water, or at some distance from the base or ship. It is necessary that assistance be prompt and efficient. Hospital corpsmen serving as aviation technicians should be experts in the resuscitation of the apparently drowned. The ambulances and crash boats should be provided with crash gear as a ready means of extracting the injured from the wreckage. Especially is this important where the wreckage is submerged, or where fire may be an added hazard. (*See* Paragraph 1261, Section 3, Chapter 10, Manual of the Medical Department, U. S. Navy.)

Section 2.—BASAL METABOLISM

GENERAL CONSIDERATIONS

In discussing this subject certain general and basic considerations will be given first in order that the reader may form an accurate conception of what is meant by basal metabolism. Nor is it considered necessary to illustrate this chapter with pictures, tables, and charts, for the apparatus can be seen in operation in any naval hospital and at the U. S. Naval Medical School. Technique will be dealt with only as necessary for clarity. Specific technique is furnished in detail by the manufacturers of each type of apparatus and should be followed to the letter.

By **metabolism** is meant all those chemical reactions (oxidation, reduction, hydrolysis, synthesis, etc.) occurring within the tissues of the living body. These reactions are constantly going on as long as there is life and are both constructive (anabolic) and destructive (katabolic) in nature. Such chemical changes form the basis of the various physiological processes and functions.

Oxidation is the chemical reaction with which one is concerned in basal metabolism. Oxidation gives rise to energy. When anything burns (oxidizes) inside or outside the body, slowly or rapidly, heat is produced, and heat can be measured. It is common knowledge that the body is always warm, and by use of the clinical thermometer one may see that the temperature of the body remains remarkably constant regardless of most influences, as climatic conditions, which would markedly affect the temperature of inanimate objects. This is due to the delicate mechanism which adjusts the relationship of heat loss and heat production, somewhat analogous to the thermostat of an incubator, but much more complicated. (*See* any text book on physiology.) But the clinical thermometer is a qualitative measure of heat only and in fevers it indicates that oxidation has speeded up, but it gives no accurate idea as to the *amount* of heat actually being produced. In basal metabolism a quantitative measure of heat is determined, and, with this fact known, an idea of the *intensity* of oxidation going on may be had, and certain deductions can be drawn therefrom. For this purpose the large calorie (C.) is used as the unit measure of heat, this calorie being that amount of heat necessary to raise the temperature of 1000 grams of water from zero to 1° C.

Oxidation of what?—Many substances undergo oxidation in the body, but the oxidation of carbohydrates (glucose), fats, and proteins (amino acids) constitutes such a large percentage of the whole that for practical purposes no others need be considered so far as basal metabolic work is concerned. These basic food materials when burned within the body or in a bomb calorimeter produce practically the same amount of heat, the caloric value being given in round numbers as follows: 1 Gm. of carbohydrate, 4 C.; 1 Gm. of protein, 4 C.; and 1 Gm. of fat, 9 C.

During oxidation glucose and fats are completely broken down into CO_2 and H_2O, the CO_2 being eliminated by the lungs in exchange for oxygen from the air, and the H_2O being eliminated through the lungs, skin, kidneys, and other excretions. Amino acids, on the other hand, are not completely oxidized. Amino acids are used to synthesize proteins to replace those lost by wear and tear, to promote growth, and for fuel, if needed. The by-products of oxidation are H_2O, CO_2, urea, etc., while 58 per cent may be used to synthesize glucose which may be further oxidized if needed. Approximately 15 per cent of the total calories is derived from proteins, the rest from carbohydrates and fats. The chemical reactions may be expressed as follows:

$C_6H_{12}O_6$ (glucose) $+6O_2=6H_2O+6CO_2=4$ calories per gram of glucose or 5.05 calories per liter of oxygen consumed; and

$2C_{57}H_{110}O_6$ (tristearin) $+163O_2=110H_2O+114CO_2=9$ calories per gram of fat or 4.69 calories per liter of oxygen consumed. Proteins, however, are not completely oxidized in the body as in the laboratory (bomb calorimeter) and the caloric value is 4.0 calories per gram or 4.485 calories per liter of oxygen consumed.

The **respiratory quotient (R. Q.)**.—From the foregoing it may be observed that the amount of oxygen required to oxidize a given amount of carbohydrate, protein, or fat will differ in each case and that the caloric value of one liter of oxygen will vary according to which substance is being burned. This will become clearer by study of the respiratory quotient (R. Q.).

The R. Q. is the volumetric relation of the oxygen consumed to the carbon dioxide eliminated, i. e., the amount of CO_2 divided by the amount of O_2. Under similar conditions of atmospheric pressure and temperature equal volumes of different gases will contain an equal number of molecules, or, in other words, a given number of molecules of different gases will occupy equal volumes. (*See* Avogadro's Hypothesis, p. 656.) Consider the following equations:

1. Oxidation of glucose:

$$C_6H_{12}O_6+6O_2=6H_2O+6CO_2. \quad \text{Then R. Q.}=\frac{6 \text{ vol. } CO_2}{6 \text{ vol. } O_2}=1.0$$

It will be observed that when glucose is oxidized all the oxygen used (or added) is consumed in the formation of CO_2 and that for each volume of oxygen used one volume of CO_2 is given off. Hence an R. Q. of unity.

2. Oxidation of fat (palmitin, for example):

$$C_{51}H_{98}O_6+72.5O_2=51CO_2+49H_2O. \quad \text{Then R. Q.}=\frac{51CO_2}{72.5O_2}=0.703$$

It will here be observed that fat contains a relatively smaller amount of oxygen than does glucose; hence more oxygen is required to burn this substance. This results in a low R. Q.

In a more or less similar manner it may be shown that the R. Q. for proteins will be between these extremes at about 0.80. The R. Q. will again vary according to what particular fat or protein is being oxidized.

Now the human body probably never burns only one food stuff at a time, but it is constantly oxidizing a mixture of all three. By the determination of the R. Q. and by reference to the appropriate table one can estimate the proportion of protein, fat, and carbohydrate being oxidized at one time. For accurate metabolic work the R. Q. must be determined because the caloric value of a given amount (1 liter) of oxygen will depend upon it, this fact entering into the calculation of the **Basal Metabolic Rate (B. M. R.)**. For practical purposes, however, it has been found that after 14 hours of fasting the R. Q. is rather constant at 0.82, and this figure has been chosen for routine use in clinical basal metabolism, the determination of the R. Q. being dispensed with.

At this point one might consider basal metabolism as the amount of heat, expressed in calories, produced by the body in a definite length of time under basal conditions. But this is only a partial definition which is not yet sufficiently clear, for as yet the conditions termed basal and the factors influencing the rate of oxidation have not been discussed.

Factors influencing the rate of oxidation and hence the B. M. R.—1. The *thyroid gland* is a gland of internal secretion producing a complex chemical substance containing iodine (*see* page 62). This substance is thyroxin, the thyroid hormone. It has a powerful influence on the rate of metabolic activity through its catalytic action. Overactivity of the thyroid (hyperthyroidism, toxic adenoma, exophthalmic goiter) produces more than the normal amount of thyroxin and stimulates oxidation, whereas a decrease in thyroid activity (hypothyroidism, cretinism, myxœdema, surgical removal, X-ray) causes a reduction in the normal amount of thyroxin and a decrease in the rate of oxidation. It has been estimated that about 15 mg. of thyroxin is normally present outside the gland, and that the thyroid must manufacture ⅓ to 1 mg. of thyroxin daily to maintain this concentration. Other *glands* (pituitary, adrenal, ovary, testis) influence metabolism but to a less marked and less understood degree.

2. In general any condition associated with *increased cellular activity* is likewise associated with an increased B. M. R. (leucæmia, fever, etc.). For each degree of fever (Fahrenheit) the B. M. R. is increased about 6.2 per cent.

3. *Exercise* stimulates oxidation to a marked degree, so that a person at rest will have a very different B. M. R. from what the same person will have shortly after exercise. *Muscular tremor* will do the same.

4. *Digestion of food* also increases metabolism to a great degree. After 14 hours of fasting this factor is eliminated.

5. The *mental state* of the patient, (worry, apprehension, excitement, pain) increases metabolic activity.

6. *Anæmia* and *heart disease* may cause an increased B. M. R., due to increased activity of the heart and muscles of respiration.

7. *Age.*—Metabolism increases slightly to the age of 6 years when there is a rapid decrease to the age of 20. After that there is a very gradual decline with age. At 75 years of age, the B. M. R. is about 30 per cent less than at the age of 15.

8. *Sex.*—On the whole basal metabolism is about 7 per cent less in the female sex. The reason is not evident. Before the age of puberty there is still a definite but less marked difference. During pregnancy the metabolism is increased due to the metabolic activity of the fœtus. There is also about a 10 per cent rise shortly before and during menstruation.

9. *Race* has a slight influence. The B. M. R. is said to be somewhat lower in occidental races who are noted for their repose and low protein diets. On the other hand the Esquimo, who is exposed to cold and who is a heavy meat eater, has a higher rate.

10. *Proteins* have a definite stimulating action on metabolism in addition to the energy released by their mere combustion. This has been called by Rubner the specific dynamic actions of foods and is observed mostly with proteins. This dynamic action of proteins lasts for many hours and, after a heavy protein meal, may be observed the next day.

11. Metabolism is reduced during *sleep* to 10 or more per cent below that under basal conditions. This is probably due to lessened heart and respiratory activity.

12. *Drugs.*—Sedatives and narcotics will reduce the rate. Thyroid extract, dinitrophenol, certain pituitary preparations, caffeine, and epinephrine will increase the rate.

What is meant by basal conditions.

Various factors have just been discussed as influencing the basal metabolic rate. With few exceptions these factors revise the rate upward. But not all of these factors render abnormal figures. In preparing a patient for a metabolic test as many of these factors as possible must be eliminated or reduced to a minimum. The more important factors are food, exercise, the mental state, drugs, and adequate rest prior to the test. Hence, if a patient has not eaten for 14 hours, is mentally calm and not suffering from pain or other discomfort (as a full bladder), has not had certain drugs within a reasonable period, has had a good night's rest, and has been at complete rest for one-half hour immediately before the test, he is said to be under basal conditions. Under basal conditions the B. M. R., is as low as it is possible to get it while the patient is awake and not under the influence of drugs. As all patients are similarly prepared, comparison can be made in the B. M. R. of different patients or in the case of the same person at different times.

Relation of B. M. R. to height, weight, surface area, age, sex.

For comparative purposes it is not enough merely to do the test under basal conditions. There must be other criteria for comparison. In arithmetic a common denominator is found when one wishes to compare the values of common fractions, for example, to compare $1/3$ and $2/5$ a much better conception is had by finding a common denominator and studying the fractions as $5/15$ and $6/15$. In basal metabolism a common denominator must be found. One cannot compare the total metabolism of a large man with a small one even though they be the same height and age. Nor would one expect the B. M. R. to be

the same in an old man and a young woman of the same height and weight. Various methods have been tried and it has been found that the metabolism is not directly proportional to age, sex, height, weight, or any other convenient standard. It is believed to be proportional to muscle mass, but there is no way of determining muscle mass. It has, however, been found that the metabolism is directly proportional to surface area. But while one person may have 1 square meter of surface area, another 2 square meters and so on, metabolism is proportional to a given unit of that area, namely, 1 square meter. Regardless of the total area, the metabolism of 1 square meter of surface area of one person can be compared to that of 1 square meter of surface area of another person, both being under basal conditions. The surface area may be calculated with considerable accurateness by the following formula of DuBois:

$$A = W^{0.425} \times H^{0.725} \times 71.84 \text{ where } A = \text{Area};$$
$$W = \text{Weight in kilograms; and}$$
$$H = \text{Height in centimeters}$$

The mathematical calculations required by this formula ordinarily need not be performed for it generally is necessary only to determine the height in inches or centimeters, the weight in pounds or kilograms, and then refer to a chart based on the above formula and read at a glance the surface area in square meters. Ordinarily a healthy adult under basal conditions produces about 40 calories per square meter of body surface per hour. It is customary to express the results in percentage above or below a base line called zero. The normal range lies within plus 15 per cent to minus 10 per cent (above or below the base line).

Definition.

From the foregoing it is possible to define basal metabolism as the minimum oxidative or heat-producing metabolism of which a person is capable while awake and not under the influence of drugs, the results being expressed in calories per square meter of body surface per hour. The basic metabolism rate (B. M. R.) is the same except that it is expressed in percentage above or below a normal base line of zero.

APPARATUS

In the determination of basal metabolism two types of apparatus are used which operate on the principles of *direct calorimetry* and *indirect calorimetry.*

Direct calorimetry requires a large apparatus, built somewhat on the order of a bed room, in which a person may live for specified periods of time, and the actual amount of heat given off in calories determined. It is a most accurate method suitable for research work, but it is too expensive and complicated for routine clinical use. Apparatus for determining basal metabolism by this principle have been devised by Atwater, Benedict, Rich and Lusk, Murlin, DuBois, and others.

Indirect calorimetry is the method of choice for clinical use and is sufficiently accurate for such use. One make of this type of apparatus, the Benedict-Roth, not only determines the amount of oxygen consumed but also the amount of CO_2 eliminated, so that the respiratory quotient can be determined and used in the calculation for each patient. This type of apparatus, too, because of its more exacting technique and greater expense, has been largely supplanted by simple ones as the Sanborn, the Jones motor basal, etc. These simple apparatus measure the amount of oxygen consumed only. As pointed out before, under basal conditions the R. Q. is rather constant at 0.82 and thus may be used for practical purposes. As a matter of fact either the oxygen

alone or the CO_2 alone could be used in the calculation, but it has been found more practical and accurate to use oxygen consumption alone, and most apparatus for clinical use have been devised accordingly.

TECHNIQUE

Preparation of the patient.

This has been mentioned before, but it is of the greatest importance, and each patient must be given specific instructions in writing prior to the test. It is also important prior to the test to ascertain if these instructions have been carried out. Nor is it essential for the patient to remain in a hospital overnight for this test. A nervous patient would probably obtain a better night's rest at home and could then report to the metabolic laboratory by the least exertion possible and rest in bed one-half hour in the laboratory.

"Before giving patient his instructions, assure yourself of the following:

"1. Assure yourself the day before the test that the patient:

"(*a*) Has not received thyroid preparations within a month and is not receiving dinitro-o-cresol, dinitrophenol, caffeine or adrenalin.

"(*b*) Is not suffering from toothache, earache, headache, or any other cause of continued pain.

"(*c*) Is not having fever or chills at any time of day.

"(*d*) Is not menstruating, or due to menstruate within the next 48 hours.

"2. Explain to the patient the harmless nature of the test and the importance of following instructions explicitly." (Osgood.)

The following is an example of printed instructions for the patient:

"(*a*) Eat a light evening meal about 6 p. m., containing very little protein (meat).

"(*b*) Take nothing of any kind whatsoever after this meal until after the test is completed the next morning. If very thirsty, a little water at body temperature an hour or more before the test will do no harm, but milk or coffee or any other food or beverage must not be touched unless specifically permitted. A glass of orange juice several hours before the test will not introduce any material error.

"(*c*) Spend the evening quietly at home, or preferably in the hospital, and go to bed by nine o'clock. It is probably better not to smoke within 2 hours of the time set for the test.

"(*d*) Choose the method of transportation to the place where the test is to be done that will involve the least exertion. It is still better if the patient can spend the night in the room where the test is to be done.

"(*e*) Arrive at the hour specified, preferably 8 a. m." (Osgood).

The test.

The simple, less expensive, portable, and easily operated apparatus consist essentially of a closed circuit containing a sealed container of oxygen at one end and the patient at the other, connected by means of tubes and a mouth piece. There is a motor blower to facilitate the circulation of the gases and to make breathing easier. In the circuit there is also a soda-lime container to absorb CO_2 from the patient and thus keep the oxygen pure. The oxygen container is equipped with a thermometer because correction for temperature must be made. The barometric pressure is read from a barometer. By means of a kymograph attached to the machine the amount of oxygen consumed in a specified time (say 6 minutes) may be read and then calculated for one hour. Now, having obtained certain specific data (age, sex, height, weight, surface area,

amount of oxygen consumed corrected to a barometric pressure of 760 mm. mercury and a temperature of 0° C.) the calculation of the basal metabolism and the B. M. R. may proceed. This is readily done by arithmetic and reference to certain tables and charts. Use the formula:

$$\frac{\text{Loss of } O_2 \times (\text{factor corrected to 760 mm. and } 0^\circ \text{ C.}) \times \frac{1 \text{ hour}}{\text{time of test}} \times 4.825}{\text{Sq. M. of body surface}} = \text{B.M.R.}$$

Example: "Patient: Male 29 yrs., 5 ft. 8¾ in., 147½ lb.
Body surface: 1.8 sq. M.
Time of test: 5 min., 7 sec.
Bar. 30.11 in.
Temp. of O_2 at start, 23.5 C. Factor 0.926
Vol. O_2, 7200 cc.
Temp. of O_2 at end, 24.0 C. Factor 0.925
Vol. O_2, 4900 cc.
$7200 \times 0.926 = 6667.2$ cc.
$4900 \times 0.925 = 4532.5$ cc.
2134.7 cc., or 2.1347 liters of O_2 at 760 mm and 0° C.

$$\frac{2.1347 \times \frac{3600}{307} \times 4.825}{1.8} = 67.1 \text{ Cal.}$$

39.5 Cal. (Normal)
27.6 Cal. per hour per sq. M. body surface above normal.
$x : 100 = 27.6 : 39.5$
$x = 69.87\%$ or B. M. R. is approximately 70% above normal, or + %." (Stitt).

As a matter of fact the calculation has been greatly simplified in recent years by use of a slide rule. In the case of the Jones motor basal apparatus the correction for pressure and temperature is automatic. It is then only necessary to apply certain factors as to height, weight, age, sex, etc., to the slide rule and read off the B. M. R. direct.

The technique supplied by the manufacturers with each type of apparatus goes into detail and should be followed. This literature also must be followed in regard to the care of the apparatus and how to test it at regular intervals for efficiency. Efficiency in doing basal metabolic work comes only with an understanding of the principles involved and with practice.

CLINICAL SIGNIFICANCE

For clinical purposes basal metabolism has boiled itself down almost entirely to a study of the thyroid gland. It is important in the diagnosis of thyroid disturbances. In hyperthyroidism the B. M. R. will range anywhere from plus 20 per cent to plus 100 per cent or more depending on the severity of the case. In hypothyroidism rates of minus 15 per cent or lower are common. In myxœdema minus 40 per cent is not uncommon. As a rule a series of two or more readings should be made to get an average and to get the patient accustomed to the test. This is especially important if the first reading is abnormal. The test is of great importance in following cases on thyroid therapy but this of course does not represent the patient's true metabolism. The B. M. R. at intervals is also necessary while a patient is on Lugol's solution prior to operation in order to determine the best time to operate—when the B. M. R. is plus 30 per cent or less and before it has started to rise again.

The total metabolism (number of calories in 24 hours) is of some importance in calculating basic diets for diabetics and obese persons.

Basal metabolism has been of great value in research work and has thrown much light on the problems of nutrition.

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Section 3.—BLOOD GROUPING AND MATCHING

HISTORY

Blood transfusion, the term used for the process of transferring blood from one person to the circulation of another, is often a life-saving remedy, especially in cases of severe hæmorrhage, anæmia, and infections.

The use of blood as a therapeutic agent is as old as medicine itself. The ancients drank fresh blood and even bathed in it for the purposes of resuscitation, recuperation, and rejuvenation. There are vague references that transfusion was practiced, but it is not until the early part of the seventeenth century that authentic references to transfusion are to be found.

William Harvey, in 1616, when he propounded the theory of the circulation of the blood, made the first important contribution which made possible blood transfusion as it is known today. Immediately following Harvey's theory as to the circulation numerous human beings were transfused with the blood of various animals, mostly with dire results. A few successful transfusions of blood from one human being to another were done, but usually there were severe reactions and numerous deaths, so that blood transfusion soon fell into ill repute. It was considered extremely hazardous and only to be used as a last resort.

The modern period in the development of blood transfusion began in 1900 when Landsteiner discovered iso-agglutinating and iso-agglutinable substances in human blood. The following year he divided blood into three groups with regard to their agglutinable reactions. In 1902 Decastello and Sturli added a fourth group. In 1907 Jansky worked out the reciprocal agglutinating reactions of the four groups, and in 1910 Moss, working independently, confirmed Jansky's work. It was also found if the blood of the donor was of the same group as that of the recipient transfusion could be safely done. It was Landsteiner, then, who provided the basis for the present methods of determining the compatibility or incompatibility of blood for transfusion.

Classification.

Three separate classifications of the four blood groups are in common use, the Jansky, the Moss, and the Landsteiner or International. The International classification is recommended by the American Association of Immunologists and by the Health Committee of the League of Nations, and was adopted by the Medical Department of the United States Navy in 1928. The International classification designates the four blood groups by the Roman capitals O, A, B, and AB, and to avoid confusion no further mention will be made of the other classifications, except for a correlation of the groups shown in the table on page 858.

Agglutination.

The work showing that all bloods can be classified into four groups was done by random cross matching of the bloods of a large number of people. Two specific antigens, the iso-agglutinogens or the agglutinable substances, designated by the capital letters A and B, were found to be distributed in the red cells. Two anti-bodies, the iso-agglutinins or the agglutinating substances, identified by the small letters a and b were found in the sera. Hæmolysins are also present in sera, but since hæmolysis does not occur without being preceded

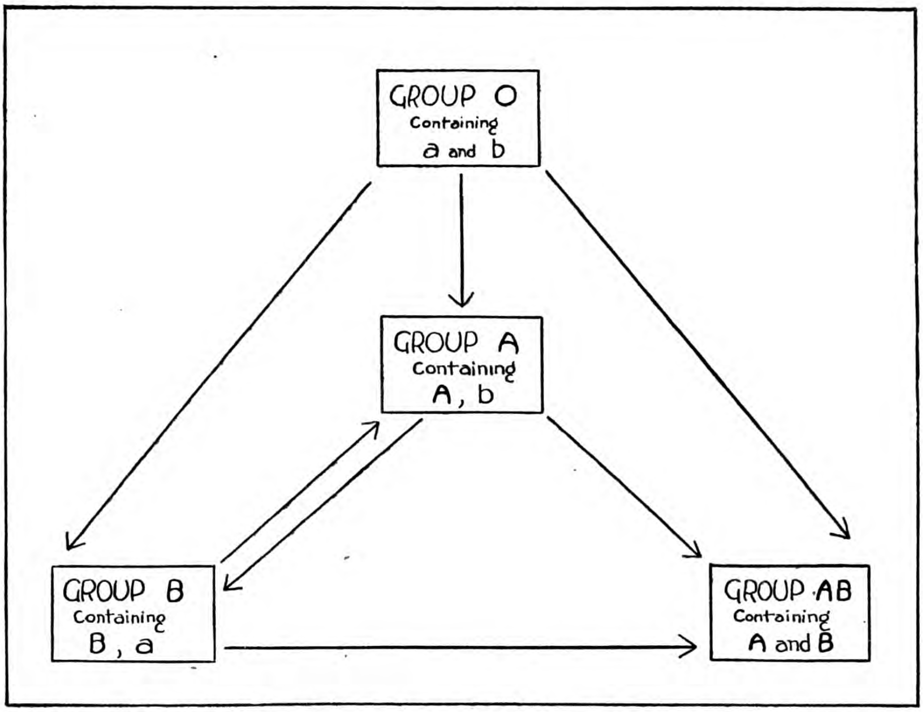

FIGURE 158.—Diagram showing the interrelationship among the blood groups.

by agglutination they can usually be ignored in grouping bloods. The iso-agglutinogens and iso-agglutinins are so distributed that an iso-agglutinogen and its corresponding iso-agglutinin are never present simultaneously in the same blood. The table following shows the distribution of the iso-agglutinogens and the iso-agglutinins in the various blood groups.

Distribution of the iso-agglutinogens and iso-agglutinins in the four blood groups

International group	Agglutinogens in red cells	Agglutinins in serum	Percentage of individuals in group
O	None	a and b	43
A	A	b	40
B	B	a	7
AB	A and B	None	10

A blood serum containing a given agglutinin will agglutinate red cells containing the corresponding agglutinogen and will not effect other red corpuscles, so from the table it is seen that the various groups are classified according to the agglutinogen content of the red cells. The interrelationship among the blood groups is more plainly shown in figure 158.

The serum of any group will agglutinate the red cells of any group toward which the arrows point. No arrows point toward Group O for its red cells contain no iso-agglutinogens and its cells are not agglutinated by the serum of any of the other groups; therefore individuals of this group are sometimes called "universal donors." Conversely, no arrows point away from Group AB for it contains no agglutinins and its serum will not agglutinate the cells of any other group, and individuals of this group are often spoken of as "universal recipients." However, such bloods must be studied, when cross matched, before being declared suitable. The question of universal donors will be further discussed under the heading of precautions.

To determine the group to which a blood belongs it is necessary to mix separately a suspension of its red cells with serum of a known group A and group B which contain agglutinin b and agglutinin a, respectively. The resulting agglutination, or absence of agglutination, determines the group to which it belongs and is a necessary procedure with the blood of both the donor and recipient. One of four possible combinations of reactions, as shown in the following table, will result:

AGGLUTINATING REACTIONS OF THE RED CELLS OF THE FOUR BLOOD GROUPS

International blood group	Serum A (b)	Serum B (a)	Jansky blood group	Moss blood group
O	−	−	I	IV
A	−	+	II	II
B	+	−	III	III
AB	+	+	IV	I

− Denotes absence of agglutination.
+ Denotes presence of agglutination.

TECHNIQUE OF BLOOD GROUPING

Preparation of grouping sera.

Grouping sera A and B can readily be prepared, but are usually obtained from some large or central laboratory. Under absolutely sterile precautions collect blood by venipuncture from healthy young adult males of blood group A and of blood group B. Allow the bloods to clot, then loosen and separate the clots from the sera by centrifuging. Pipette off the sera and determine their agglutinating power by titration of varying dilutions of the sera against proper red cell suspensions.

For the purposes of preservation and distinctive coloration, to each cubic centimeter of serum A add 0.01 cc of a 1 per cent aqueous solution of neutral acriflavine and 0.01 cc of a 0.5 per cent aqueous solution of basic fuchsin, and to each cubic centimeter of serum B add 0.02 cc of an aqueous solution of brilliant green. Store in ampules or vials of suitable size.

Preparation of the suspension of red cells to be grouped.

As fresh cells are necessary this procedure should be done immediately, at least not more than 2 hours, before the test is to be done. From a needle prick of the finger, or of the ear lobe, collect two drops of blood (four drops if anæmic) in a small test tube containing 4 cubic centimeters of 1 per cent solution of sodium citrate made up in 0.85 per cent sodium chloride solution. Mix thoroughly by sucking the mixture up and down with a clean medicine dropper which is left in the tube for future mixture and transference.

Procedure for grouping.

Slide Method.—When only a few bloods are to be grouped this method will be found convenient and satisfactory. With a blue wax pencil mark a capital letter A on the left end of a clean, double, hollow-ground slide, and on the right end a capital letter B; then rim the concavities with petrolatum. In the left concavity place one drop of grouping serum A and in the right, one drop of grouping serum B. Then to each add one drop of physiological salt solution and one drop of the red-cell suspension. The sera, salt solution, and cell suspension are mixed thoroughly by stirring with individual clean toothpicks or by rotating and tilting. Drop a cover glass on the petrolatum ring to prevent evaporation. The preparation is then examined at intervals under the low power lens of a microscope for the presence or absence of agglutination. Agglutination usually takes place in from 5 to 10 minutes, but if it does not the preparation should be inspected at intervals for 1 hour because the agglutinogens may be weak and the red cells may not clump for 45 minutes or more. If agglutination takes place the red cells gather in dense, irregular groups which appear to the naked eye as "brickdust" granules which will not be broken up by stirring or shaking. If there is no agglutination, the red cells will be fairly evenly distributed over the field and will remain so for hours.

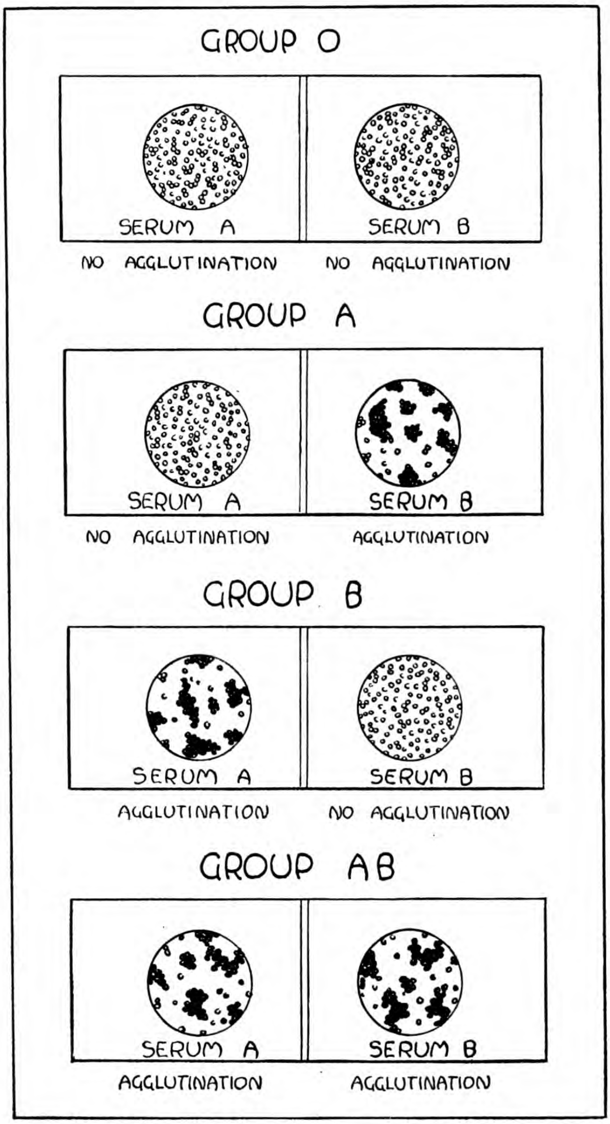

Figure 159.—Agglutinating reactions of the red cells of the four blood groups with grouping sera A and B. Slide method. (Magnification about 100 x.)

Caution: Droppers must only be used in their respective sera and cell suspensions. Toothpicks used for mixing serum A and the cell suspension must not be used for mixing serum B and cell suspension, and vice versa.

For interpretation of results see table on page 858 and figure 159.

TEST TUBE METHOD.—When a large number of bloods are to be grouped this method is recommended. Set up a double row of test tubes, measuring 1.0 cm. inside diameter by about 7.5 cm. long, in Kahn or other suitable test tube racks. Each pair of tubes is numbered consecutively, i. e. both tubes of the left hand pair are labeled #1, the next pair #2, etc. Deliver to the bottom of each tube in the front row one drop of serum A, to the bottom of each tube in the back row one drop of serum B, and to the bottoms of all tubes one drop of physiological salt solution. Then to each tube of pair #1 add one drop of the cell suspension of the first blood to be grouped, and to each tube of pair #2 one drop of the cell suspension of the second blood to be grouped, etc., being careful that the cell suspension reaches the bottoms of the tubes, not the side walls. Give each rack a few short quick shakes to mix the contents of each tube. Observe and shake several times over a period of 1 hour, giving the tubes a final shaking at the end of the hour, at which time the final reading is made. If there is agglutination red clumps of cells may be seen by the naked eye, but if agglutination is doubtful or is apparently negative, transfer the contents of the tubes in question to a glass slide and observe under the low power lens of the microscope. The same *cautions* concerning droppers, etc., applies as in the slide method. There will be very little evaporation from the tubes during the time taken to perform the tests. Greater quantities of grouping sera, saline and cell suspension may be used, but the given amounts are satisfactory and grouping sera are not wasted.

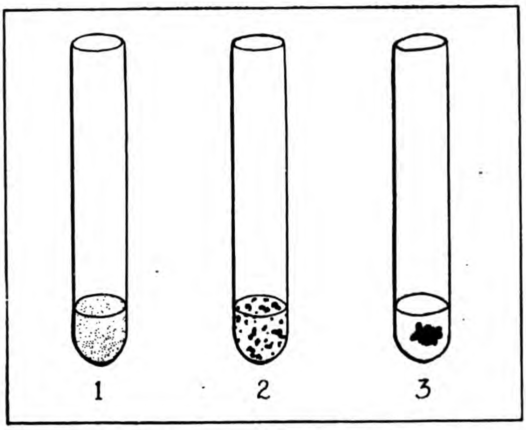

FIGURE 160.—Agglutinating reactions of red cells: test-tube method. 1. No agglutination. 2. Agglutination in numerous small clumps. 3. Agglutination in one large clump. (All after shaking.)

For interpretation of results see table on page 858 and figure 160.

Cross matching.

When the recipient's or patient's blood group is ascertained, a donor of the same group is obtained. From a vein of the patient draw 3 or 4 cc of blood into a syringe. Using two drops of the blood prepare a cell suspension, as previously described. Place the remaining blood into another tube and allow to clot in order to obtain the serum as described under preparation of grouping sera. Blood from the donor is similarly collected and treated. Mark a double hollow-ground glass slide as shown in figure 161. On the left side place one drop of the patient's serum and one drop of the donor's cell suspension. On the right side place one drop of the donor's serum and one drop of the patient's cell suspension. Mix and proceed as in the slide method of grouping. If no agglutination or hæmolysis on either side takes place in 60 minutes the bloods are compatible. If agglutination or hæmolysis takes place on either side, or both sides, they are not compatible and another donor must be cross matched. However, in extreme emergency a blood may be used for transfusion which shows agglutination or hæmolysis of the patient's cells by the donor's serum, as the donor's serum is greatly diluted in the patient's blood. If the serum of the

patient agglutinates or hæmolyzes the donor's cells the blood of the donor must not under any circumstances be used in transfusing the particular patient.

Precautions.

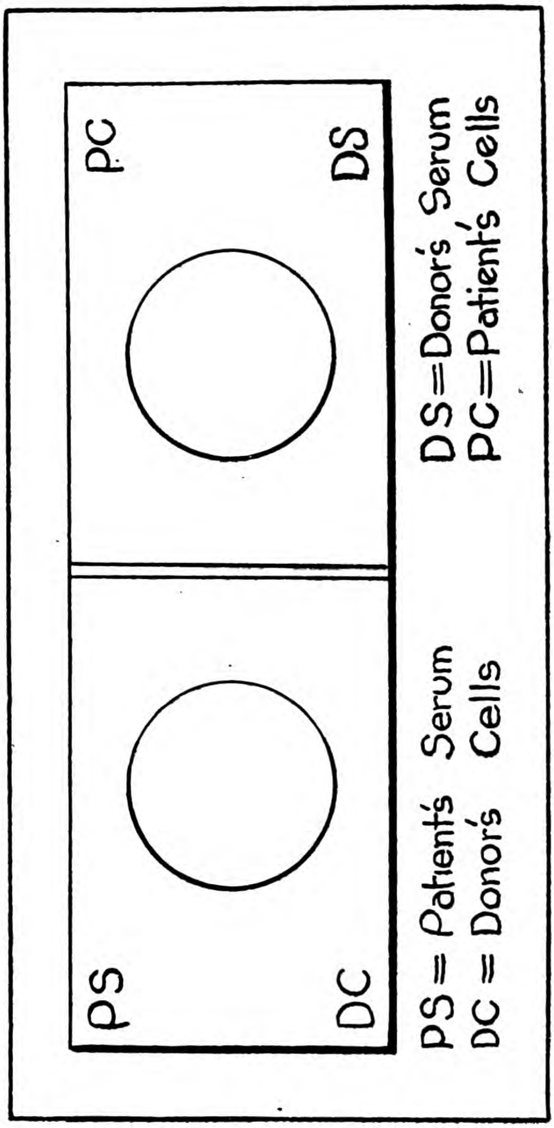

FIGURE 161.—Slide marked for cross matching.

1. Grouping sera of high agglutinating titre must be used to avoid false negative reactions, but the titre should not be high enough to cause rapid hæmolysis as it will mask the results. Freshly prepared grouping sera are more likely to cause hæmolysis.

2. Stock grouping sera should be checked frequently for deterioration.

3. Avoid low temperatures in doing the test as it will occasionally bring out a so-called "cold agglutinin", besides slowing up the reactions. Room temperature or 37° C. is best.

4. Do not let preparations dry out—the reason for the petrolatum ring.

5. All suspension must be fresh or the cells may be agglutinated by all sera.

6. Avoid too heavy cell suspensions and keep them mixed to cut down rouleau formation which might be mistaken for agglutination.

7. Weak agglutinogens or agglutinins may lead to false group determinations or cross matchings, so allow the full hour's observation in doubtful or apparently negative reactions and observe under the microscope before the final conclusion is made.

8. In cases of repeated transfusions cross match before each transfusion, even though the same donor is to be used and was previously compatible. Iso-antibodies may have developed in the blood of the patient and cause a severe reaction.

9. The so-called "universal donors", i. e. those of group O, are frequently used as it is assumed that their cells are not agglutinated by any human sera. Severe and even fatal reactions have occurred because certain group O sera contain strong agglutinins for A cells or B cells, or for both. It is better that the recipient and donor be of the same group.

10. Be certain all slides and tubes are labeled correctly and that the results are recorded correctly and properly.

11. Cross match before every transfusion as it may save much embarrassment.

SELECTION OF A DONOR

The donor must be a healthy individual, preferably a young male, free from infectious diseases. Syphilis and malaria must be excluded. A Kahn or Wassermann test should be done on every donor just prior to giving blood for a transfusion, but a history and careful physical examination are also necessary. Syphilis has been conveyed by blood from donors with primary syphilis but whose Wassermann reactions were negative. Malaria has been transmitted, even from old latent cases. It is much safer to reject all donors with a history of syphilis or malaria even though their bloods are negative.

A donor should not be used a second time until his blood volume, hæmoglobin and red cell count have returned to normal; which is usually from 4 to 6 weeks.

References

Practical Bacteriology, Hæmatology, and Animal Parasitology.—Stitt, Clough, & Clough.
Diseases of the Blood and Atlas of Hæmatology.—Kracke and Garver.
Laboratory Manual of Hæmatological Technique.—Beck.
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Section 4.—CHEMICAL WARFARE

The subject of chemical warfare is a matter of considerable importance to the Hospital Corps of the Navy for several reasons. While an authentic instance of the use of poison gas at sea is lacking, it is possible that it may be used in naval battles of the future. Hospital corpsmen are subject to detail with the Marine Corps in operations ashore, in which case their problems are identical in most respects with those of the medical department personnel of the Army. Furthermore, it may develop upon the Hospital Corps to assist ashore in the care of casualties among the civilian population and in the care in naval hospitals of patients suffering after-effects of war poisoning who formerly were attached to and received their injuries during service in the Army or the Marine Corps.

The hospital corpsman should have a thorough knowledge of the following aspects of chemical warfare: History of chemical warfare; general information about the chemical warfare agents; methods of use of agents in weapons and munitions; protection, individual and collective; and decontamination of material. The book "Service Chemicals, United States Navy, 1936", should be used for this instruction. The paragraphs following will describe the physiological action of these agents and the first aid to chemical casualties.

MEDICAL ASPECTS OF CHEMICAL WARFARE

The important chemical warfare agents are few in number, but during a war new agents or new combinations may be expected at any time. To better understand the actions of these agents they will be divided or classified according to their physiological action on man. It is impossible to draw hard and fast lines of distinction as the groups overlap somewhat in their physiological

effects. The agents used in chemical warfare are physiologically classed as:

1. *Lacrimators* (tear gases); Example: Chloracetophenone (CN);
2. *Irritant smokes* (sternutators, sneeze gases); Examples: Diphenylchlorarsine (DA); Diphenylaminechlorarsine (DM);
3. *Burns secondary to incendiaries;* Examples: Thermit; White Phosphorus;
4. *Lung irritants;* Examples: Chlorine (Cl); Phosgene (GG); Chlorpicrin (PS); (Secondary to explosions: Nitrous fumes; Irritant effects of ammonia fumes);
5. *Vesicants;* Examples: Mustard gas (HS); Lewisite (M–1);
6. *Paralysants* (direct poison of nervous system); Example: Hydrocyanic Acid (HCN); and
7. *Asphyxiants* (secondary to explosions); Example: Carbon monoxide (CO).

Generally speaking, all of the gases in a given group will manifest similar actions and produce similar effects; therefore, with slight modifications, a single description for a particular group will suffice for all the members of that division. However, it must be understood that high concentrations of lacrimatory, vesicant, and sternutatory gases may cause severe lung injury and eye irritation.

The summary of symptoms and first-aid treatment of casualties caused by exposure to chemical agents (Fig. 162) is included for quick reference in study and during an emergency.

Lacrimatory gases.

Physiological Action.—Lacrimatory gases, such as chloracetophenone and brombenzylcyanide, are used for the purpose of putting men out of action by interfering with their vision, and not with the idea of producing serious casualties. Small traces of these substances cause profuse lacrimation, smarting of the eyes, and spasm of the eyelids, making it impossible for the individual affected to keep his eyes open. These gases produce their intended results with much lower concentrations than is required in the case of the other types of gases. Some of these lacrimatory or tear gases are effective when present in a concentration of one part of gas in 25,000,000 parts of air. Strong concentrations cause irritation of the respiratory passages, nausea, and vomiting. On leaving the poisonous atmosphere the symptoms subside in the matter of half an hour or less, depending upon the gas encountered, and no subsequent toxic effects are noted other than a slight redness of the eyelids and a moderate inflammation of the conjunctiva.

First-aid Treatment.—Affected men should leave the contaminated atmosphere and face the wind, allowing it to blow into their eyes. They should be directed not to rub their eyes; their clothing and equipment should be loosened so as to get rid of entrapped gas. Bathing the eyes in cold water or with a weak boric acid or sodium bicarbonate solution (2 per cent) will aid. For skin irritation, wash with soap and water and apply weak sodium bicarbonate solution.

Irritant smokes.

Physiological Action.—Gases of this class, typified by diphenylchlorarsine, are very effective in low concentrations, producing congestion of the upper air passages with consequent severe pain in the sinuses, irritation of eyes with lacrimation, and irritation of the lungs with a feeling of suffocation. There is excessive nasal secretion, ropy saliva, and severe headache. If exposure is prolonged, aching pains in the stomach and numbness of the limbs results. A delayed effect is severe mental depression; men seriously affected often show loss of mental control and considerable weakness of legs. Practically all casualties recover in 12 to 24 hours.

FIGURE 162.—SUMMARY OF SYMPTOMS AND FIRST-AID TREATMENT OF CASUALTIES CAUSED BY EXPOSURE TO CHEMICAL AGENTS

Symptoms in order of severity	Type of agents	Agent	Special peculiarities	Time of appearance of symptoms	First-aid treatment
Irritation of eyes. Copious flow of tears. Blindness (temporary).	LACRIMATORS	Chloracetophenone. Brombenzylcyanide. Chlorpicrin (ordinary field concentration).	Burning sensation on skin. May cause vomiting.	Immediate. Immediate. Immediate.	Remove temporarily from gas atmosphere; have man face wind. He should not rub his eyes. Bathing eyes with boric acid solution or bicarbonate of soda solution or even plain cold water helpful. Symptoms shortly disappear. Do not evacuate.
Irritation nose and throat. Watery discharge from nose. Coughing. Pain at base of nose. Severe headache. Nausea. Mental and physical depression.	IRRITANT GASES (STERNUTATORS).	Diphenylchlorarsine. Diphenylamine-chlorarsine.		Irritation immediate; other effects may be delayed 30 minutes or longer.	Put man at rest, loosen clothing, bathe nose and throat with salt water or bicarbonate of soda solution. Breathing chlorine as given off from bottle of chloride of lime beneficial. Keep away from heat. Mild cases need not be evacuated; more serious cases should be.
Burns on body.	INCENDIARIES	White Phosphorus. Thermits and solid oils.	Burning particles adhere to flesh. Cause heat burns—set fire to clothing.	Immediate. Immediate.	Immerse affected part in water to stop burning of phosphorus and pick out phosphorus particles from flesh. Apply mud or damp earth as temporary expedient if water not available. If copper sulfate solution available, apply immediately. It forms coating over phosphorus particles; stops their burning and makes them readily visible so that they may be picked out. Evacuate severe cases. Other incendiaries: Treat as any ordinary burn—bandage.
Irritation nose and throat. Coughing. Difficult breathing. Pains in chest. Retching—vomiting. Strangulation. Blue pallor—lips, ear lobes. Grayish pallor face.	LUNG IRRITANTS	Chlorine. Chlorpicrin (high concentration). Phosgene.	Intense irritation of throat; violent coughing. Lacrimation and vomiting. Nonirritating except in high concentration.	Immediate. Usually immediate. Often delayed.	Remove man from gas atmosphere; loosen clothing; keep at absolute rest lying down; do not allow to walk; keep warm with blankets, hot water bottle, etc.; give nonalcoholic stimulants—hot coffee or tea; administration of oxygen frequently required in severe cases; evacuate to aid station as soon as possible.
	VESICANTS [1]				If face has been exposed to either mustard or Lewisite vapor, bathe the eyes, nose, and throat with solution of boric acid, bicarbonate of soda, or common salt; and if vapor has been breathed. treat and handle as for lung irritant casualty.

Eye effects: Irritation. Inflammation of lids. Inflammation of cornea. Blindness (usually temporary; rarely permanent).		Mustard gas.	Skin burns not painful; no effect noticed when exposed to gas, hence its insidious character.	Delayed: Vapor—2 to 6 hrs. Liquid—15 min. to 1 hr.	Skin burns: *Mustard vapor.*—Immediate soap and water bath may prevent or lessen casualties; but no treatment is of much value after long exposure to vapor. *Mustard liquid.*—Swab affected area repeatedly with oily solvent, such as kerosene, gasoline, lubricating oil, or carbon tetrachloride (pyrene), using fresh cloth or cotton for each swabbing. Then follow with thorough scrubbing with soap and water. (Weak solution of chloride of lime, or "bleach", may be used instead of oily solvent; but this solution is irritating, and must be removed in subsequent washing.)
Skin effects: Redness or rash. Intense itching. Blisters. Ulcers. Granulation and sloughing of tissue.		Lewisite.	Vapor causes sneezing, often at once. Liquid-burns first appear as grayish splotches. Burns not painful. Secondary effects—arsenic poisoning.	Delayed: 15 min. to 1 hour.	*Lewisite vapor.*—Scrub thoroughly with soap and water; and apply dressing of ferric hydrate paste. *Lewisite liquid.*—Apply hydrolyzing agent, such as 5 per cent solution of sodium hydroxide (caustic soda); scrub thoroughly with soap and water; and apply dressing of ferric hydrate paste. Supply fresh uncontaminated clothing; and evacuate all but the most minor casualties from any vesicant as soon as possible.
Faintness, dizziness, dryness of throat, rush of blood to head, unconsciousness, death.	PARALYSANTS	Hydrocyanic acid gas.		HCN even in low concentration usually fatal in few minutes.	Respiration is *one* vital requirement. Remove patient to pure atmosphere, and begin artificial respiration *immediately*. Dashing cold water on face and chest may help to restore breathing. If available, and during artificial respiration, have patient breathe fumes of ammonia or of amyl nitrite. (Additional oxygen not necessary).
Blurring of sight, weakness of knees, roaring in ears, pain in stomach, sweetish taste, muscular weakness, unconsciousness, failure of respiration, death. Cyanosis; and usually bluish or red splotches on skin.		Carbon monoxide.		CO being odorless is frequently not detected in time to avoid it. Generally fatal.	Remove patient to pure atmosphere, and, if breathing has ceased, begin artificial respiration immediately. Dashing cold water on face and chest may help to restore breathing. Additional oxygen vitally necessary; and, if available, administer oxygen-carbon dioxide mixture. Watch out for relapse.

[1] All the vesicant agents are extremely toxic. If breathed, they cause severe inflammation of the lungs likely to result in bacterial infection and pneumonia. For effects of breathing, first aid as prescribed for lung irritants should be rendered.

FIRST-AID TREATMENT.—The slightly affected patient will recover in a short time after rest in fresh air. In the severe cases, however, the following measures are recommended. Use a 5 per cent sodium bicarbonate solution for nasal irrigation and as a gargle. Have patient inhale a low concentration of chlorine until symptoms are relieved. The concentration of chlorine evolved from a bottle of bleach will be satisfactory for this purpose. Wash the exposed surfaces of the body with soap and water.

Burns secondary to screening smokes and white phosphorus.

PHYSIOLOGICAL ACTION.—Burns resulting from screening smokes and incendiaries, except phosphorus, can be treated like a heat burn. White phosphorus is used for smoke screens and flying particles of burning phosphorus which hit the skin will continue to burn, unless smothered.

FIRST-AID TREATMENT.—Immerse the affected part in water or use a wet pad to stop the burning of the phosphorus. The solid particles should be picked out of the flesh. As phosphorus melts at 44° C. (112° F.) it is advantageous to apply hot water at this temperature or above and remove the melted phosphorus from the wounds by a gauze sponge. All particles of phosphorus must be removed as there is danger of phosphorus poisoning by absorption.

An excellent first-aid procedure, if available, is the prompt application of an approximately 2 per cent solution of copper sulfate in water; this solution forms a thin coating of copper phosphide on the phosphorus particles, and stops the burning at once, after which the coated particles can be picked out of the flesh. Apply the copper sulfate solution by pouring on or with a pledget of cotton. Dress the burned areas as for heat burns.

Lung irritants.

The common agents of this group are chlorine, phosgene, and chlorpicrin. While chlorine was used repeatedly during the World War, it probably will not be used alone to any extent in the future. Chlorpicrin may be used in future chemical warfare. Phosgene will be considered as the typical agent of this group.

PHYSIOLOGICAL ACTION OF PHOSGENE.—Phosgene is a liquid which boils at 46.8° F. with the formation of a colorless cloud. Vapor density as compared to air is 3.4 so that the vapor fills trenches and low areas. It has a characteristic odor of musty hay and is detectable in low concentrations. Phosgene is 10 times more toxic than chlorpicrin. Phosgene has a persistency of about 5 minutes in the open in summer and 10 minutes in the open in winter.

Lung irritants act upon the respiratory tract causing inflammation of these structures. Chlorine and chlorpicrin act upon the upper respiratory passages as well as the lungs. Phosgene acts primarily upon the lung tissues. The resulting inflammation of the lung alveoli hinders the oxygen exchange with the blood. The lung capillaries are injured by the gas so that the circulation of blood through the lung is impeded. The patient becomes cyanotic, a condition of blueness of the face, hands, and feet. The degree of injury to the lungs depends upon the concentration of the gas and the length of time it is breathed. High concentrations of phosgene can cause severe injury to the lungs so that œdema, a condition of fluid in the alveoli of the lungs, may appear in a short time. Usually, however, moderate concentrations of phosgene will cause a slower development of severe symptoms so that œdema appears only after several hours and after some exertion.

High concentrations of chlorine or chlorpicrin will produce immediate irritation of the throat and lungs with holding of the breath, followed by a strangling type of cough and constriction and pain in the chest. When the patient is

removed to fresh air the symptoms will be somewhat ameliorated but he will evidence a great discomfort in the chest. Vomiting, headache, and prostration are evident. A paroxysmal cough, often followed by vomiting, may remain for some time afterwards. In contrast there is a marked latent period after breathing a moderate concentration of phosgene. This interval may extend for several hours. Soldiers gassed with phosgene during the World War often walked several miles before severe symptoms appeared. This delayed action characterizes many of the lung irritant gases including nitrous fumes from burning powder.

The cases in which pulmonary œdema develops to a serious extent tend to fall into two groups. The first group—blue type of asphyxia—comprises cases which show definite venous engorgement; the face is congested and deeply cyanosed, the lips and tongue are a full blue color, and there may be visible distention of the superficial veins of the face, neck, and chest. The breathing is increased not only in frequency, but the actual amount of air reaching the lungs per minute is markedly above normal. Cough may be present, and expectoration of large quantities of thin frothy fluid is more likely to occur in this group than in the other. The pulse rate is usually little over 100 per minute and is full and of good tension. Cases in the second group—the gray type of asphyxia—show an ashen pallor rather than deep cyanosis, the lips being pale and leaden colored, and they are in a general state of circulatory collapse. Respiration is rapid and shallow in character. Though the lungs are intensely œdematous, there is often little expectoration and cough is infrequent. The pulse is very rapid (130–140 per minute), weak, and running. The prognosis is less favorable than in the first group. Sometimes a case which at an earlier stage has shown congestive cyanosis with a full pulse will develop cardiocirculatory failure and will gradually assume a gray pallor while the pulse accelerates and weakens.

First-aid Treatment.—Certain features of treatment can be carried out only by a medical officer. However, the proper handling of these cases by the stretcher and first-aid parties is very important; it is therefore necessary that hospital corpsmen be thoroughly acquainted with the therapeutic measures. Such procedures as blood letting should be understood by him so that he will be better able to assist the medical officer. In general, therapeutic measures are carried out as described hereafter.

If there is doubt that a man has been gassed by a lung irritant gas, he should be closely watched for 24 hours at the first-aid station for signs of lung irritation and be kept both warm and quiet.

Casualties should be handled as follows:

1. Remove from gassed areas or compartments.
2. Force patient to lie down so as to conserve oxygen.
3. Keep warm with blankets and hot water bottles. Give hot drinks.
4. Evacuate only by stretcher or ambulance.
5. Give oxygen by inhalation to severely affected cases.

Blood letting.—Even at the first-line dressing station the patient who presents pulmonary œdema, signs of suffocation and of cyanosis, with frothing at the lips, should be bled as soon as possible. Bleeding is contra-indicated in the gray cases. Remove 300 to 600 cc of blood from a vein, using a large bore needle.

Oxygen inhalation.—Administer oxygen by a multi-perforated nasal catheter; tip of catheter should be visible in posterior pharynx. Oxygen should be administered carefully at low pressure, and whenever possible the gas should

be passed through water. Determine a rate of flow which is both comfortable and will relieve the cyanosis, and continue the administration at this rate for about 5 out of every 15 minutes in order to conserve the oxygen supply.

POSTURAL DRAINAGE.—Elevate the foot of the stretcher or bed about 18 inches, at intervals, to aid in drainage of fluid from the upper air passages. Remove secretions from mouth and throat to aid in keeping the air passages clear.

Nitrous fumes.

PHYSIOLOGICAL ACTION.—When powder is burned, especially in a compartment, nitrous fumes are formed consisting largely of nitric oxide and nitrogen peroxide. Carbon monoxide is also present. The Navy gas mask does not protect against these gases; the oxygen breathing apparatus should be worn by those entering such a compartment.

Nitrous fumes produce a slight irritation of the eyes and upper respiratory passages, with slight cough. As in phosgene poisoning, there is a latent period, often terminated by undue exertion; symptoms of lung irritation such as cough, pain and constriction in the chest, and breathlessness ensue. If there has been severe poisoning, pulmonary œdema results as in phosgene poisoning, often terminating fatally.

FIRST-AID TREATMENT.—First-aid measures are the same as those recommended for phosgene poisoning.

Vesicant gases (blistering gases). (Mustard gas and Lewisite.)

PHYSIOLOGICAL ACTION.—*Mustard gas* possesses two properties which differentiate it from other warfare gases and render it a particularly difficult weapon to protect oneself against. These properties are persistence and insidiousness.

A single inhalation of most war gases, as for example, chlorine and chlorpicrin, causes immediate irritation and institutes a defensive reflex at once. Not so with mustard gas. The action of this poison is not accompanied at first with any painful sensation. The only warning is a faint garlic or mustard odor. Nevertheless the gas is causing changes in the skin, eyes, and respiratory tract that later will be attended with severe symptoms. Experiments have shown that a saturated vapor of mustard gas in contact with the skin for 1 minute will later produce an erythema. Those who are unfamiliar with the insidiousness of mustard gas frequently fall into the error of thinking that the absence of early irritation indicates a concentration which is too low to be harmful.

The explosion of a mustard-gas shell sprinkles the surrounding area with a heavy liquid that tends to evaporate very slowly in cold weather and quite slowly even in warm weather. Consequently, contaminated objects remain so, and are dangerous, for a long period afterwards. The heavy liquid soaks into any porous material and continues to give off toxic and blistering vapors. Hence, long after an actual bombardment has ceased there is always the possibility that there will be casualties among troops that occupy shelled areas. This has been known to happen as long as 2 weeks after a bombardment.

When dealing with lung-irritant gases one is apt to gauge the effectiveness of the gas by its killing power. It is necessary to regard mustard gas in a different light. Its value lies in its incapacitating power.

On the average the first symptoms appear 2 or 3 hours after exposure; with higher concentrations symptoms occur earlier, possibly in less than 2 hours; while with very low concentrations the appearance of symptoms may be delayed for as long as 24 to 48 hours.

The clinical picture of mustard gas poisoning, in general outline, is about as follows: Several hours after exposure there occurs a smarting of the eyes

with watery discharge, and a swelling of the eyelids. Erythema of the skin appears about the same time as the eye symptoms, usually about the face, chest, buttocks, and between the thighs.

Inflammatory manifestations of the respiratory passages begin to appear about the second day after exposure, and are characterized by pharyngitis, laryngitis, tracheitis, and bronchitis. The earliest symptoms referable to the lesions in the air passages are hoarseness and cough. Often the cough is painful and incessant. The outstanding fact in connection with these lesions is the formation of a false membrane lining the trachea and bronchi. This is the result of the direct action of the gas. The patient brings up thick purulent or bloody sputum, fragments of the false membrane, or even a cast of the portion of the trachea or bronchi.

In the World War the British, French, and American masks protected against any concentration of mustard gas attained in the field, therefore most of the cases admitted for treatment in the allied forces showed only skin lesions and conjunctivitis. Although these lesions were distressing in the symptoms they produced and kept the patient on the sick list for several weeks, rarely if ever, did they, in the absence of involvement of the respiratory organs, cause death. A fatal outcome usually is the result of the direct action of the gas on the respiratory passages or to a secondary infection in the lungs.

In the American Army there were 70,552 admissions as the result of poison gas; of these 27,711 were caused by mustard gas; 1,843 by chlorine; 6,834 by phosgene; and 577 by arsine. Mustard gas caused the loss of 1,286,784 days to the American Expeditionary Forces, as compared with 12,545,442 days lost as the result of all battle injuries. From this it would appear that mustard gas must be placed in the foremost rank as a producer of casualties. The Germans originally placed mustard gas in the smaller artillery shells, but later they employed shells of all calibers as gas carriers. Mustard gas will probably be dispersed in the future in shells, bombs, and by spray from airplanes.

First-aid Treatment.—(*a*) preventive measures. The following prophylactic measures are recommended for use after exposure to a contaminated atmosphere or when bare skin or outer clothing has been sprayed with liquid mustard. If prophylactic treatment is started immediately after contamination it will prevent, or markedly reduce, the degree of burn. Supplies should be made available so that alternative methods may be used if part of the prophylactic material is lost during action.

1. Alcohol-carbon tetrachloride mixture.—Make a mixture of equal parts of 95 per cent alcohol (ethyl) and carbon tetrachloride. The mixture is noninflammable in storage. When exposed to the air for about 1 minute it becomes inflammable, due to the evaporation of the carbon tetrachloride. Adjust masks before applying this solution as the fumes of carbon tetrachloride are toxic. While alcohol and carbon tetrachloride each are good solvents, the former is inflammable and the latter is dangerous in high concentration. Kerosene is a good solvent, but is inflammable and irritates the skin. Immediately after being contaminated with spray or splash of mustard gas, swab all exposed surfaces, using the method of swabbing described in the following paragraph. Follow the swabbing with soap-and-water wash when time is available.

Hospital corpsmen should be trained, in applying alcohol-carbon tetrachloride mixture, to use all surfaces of the gauze sponge. Do not go over the same area of the skin several times with the same sponge surface or the mustard will be spread over uncontaminated skin surfaces. Cotton sponges are not efficient for the use of solvents for swabbing. The alcohol-carbon tetrachloride mixture is a good solvent for mustard but the resulting solution must be re-

moved from the skin by the gauze. Sopping or poulticing the alcohol-carbon tetrachloride mixture on the skin will cause the mustard to penetrate widely and deeply. The gauze sponge should be used as would a rag to remove a splash of cylinder oil from the skin, at least three sponges being required for each arm or an equivalent area of skin. Each area should be gone over 3 times with the alcohol-carbon tetrachloride mixture. The flat surgical gauze sponge, 2 by 2 inches in size, is recommended. It is estimated that 12 sponges will be required for each man. At least 100 cc of alcohol-carbon tetrachloride mixture should be available for each man for one decontamination. Hospital corpsmen should wear rubber gloves, gas mask, and protective clothing. If gloves are not available for personnel using the solvents, they should sponge the hands with the alcohol-carbon tetrachloride mixture, following with soap and water, after completing prophylactic treatment. The hands may also be treated with a thin bleach paste as described in a later paragraph.

2. *Soap and water method.*—Scrub with Navy salt water soap or a strong alkaline laundry soap (yellow laundry soap) and water (preferably hot). Tincture of green soap may also be used. Sea-water may be used with the salt-water soap if fresh water is not available. The amount of mustard removed depends upon the thoroughness of the brushing of the contaminated skin. Soap and water is the medium for removal of mustard gas by emulsification. Use a flesh brush or piece of gauze with enough pressure to cause reddening of the skin surface. This brisk brushing removes some of the outer surface cells of the skin with grease, dirt, and absorbed mustard. The tender areas of the skin should be swabbed with gauze sponges. If soap is not available, or supplies for the other methods, follow the same procedure using large quantities of water. In an emergency this method will be of some benefit, if other methods cannot be used.

3. *Bleach method.*—Wet the areas of the body to be treated with water (fresh or salt) and apply a handful of bleach powder (high-test bleach) to the wetted skin and rub thoroughly, making a thin paste. Add more water or bleach powder as necessary to keep the paste thin. Allow to remain on the skin 5 minutes; remove by washing with plain water or soap and water. It may be necessary to remove the bleach paste from the tender areas of the skin in a shorter period, if the treatment causes discomfort and irritation. Keep bleach powder away from the eyes and nose; the gas mask will ensure protection to the eyes and nose. As bleach paste deteriorates on standing, the above procedure assures an active preparation which can be quickly applied.

4. *Prophylactic measures for contaminated eyes.*—These measures are to be carried out under the supervision of a medical officer. Use a 0.2 per cent chloramine solution or a 1–5000 solution of potassium permanganate, as soon as possible; apply solutions by means of eye cups, renewing solution several times. Follow this treatment by everting lids and swabbing the conjunctival surfaces, especially the fornix, with a cotton swab. (*b*) TREATMENT OF SKIN LESIONS.—The erythema requires only protection from friction and pressure, and the application of a dusting powder, or calamine lotion. Treatment of the deeper burns will be directed by the medical officer.

Lewisite as used in the field is a heavy, dark, oily liquid, and has a characteristic odor of geraniums. It will persist for 24 hours in the open in summer, and about 1 week in winter. Lewisite, unlike mustard gas, will still be effective in very cold weather. Clothing contaminated with Lewisite becomes dangerous to wear and must be removed.

PHYSIOLOGICAL ACTION.—Lewisite is very irritant to the respiratory system, and when the vapor is breathed there are immediate symptoms of nasal irri-

tation, coughing, and a subsequent bronchitis, which may lead to broncho-pneumonia. The Navy gas mask will protect against liquid and vapor Lewisite. This agent penetrates the skin on contact and causes a stinging sensation. The latent period is short, erythema and vesication resulting more rapidly than with mustard gas; erythema appears in about 15 minutes, vesication within 12 hours. If liquid Lewisite contaminates the eyes, as from airplane spray, there is immediate severe pain, lacrimation and spasm of the eyelids. The man becomes a casualty due to the ensuing inflammation of the conjunctiva and cornea.

FIRST-AID TREATMENT.—(*a*) PROPHYLACTIC TREATMENT. Immediately remove contaminated clothing and carry out prophylactic measures prescribed for mustard gas decontamination. Lewisite penetrates the skin very rapidly, hence measures, to be effective, must be used without delay. Lewisite can be neutralized by immediate application of a 5 per cent aqueous solution of sodium hydroxide (caustic soda); this should be followed by a thorough scrubbing with soap and water. (*b*) TREATMENT OF BURNS. Cleanse the skin surrounding the blisters, as recommended in minor surgery. Open blisters, removing the epithelial covering, and irrigate the raw surface with antiseptic solution. This treatment will reduce the absorption of arsenic. The burned areas should be dressed with ferric hydrate paste, spread on gauze.

Paralysants. (Hydrocyanic or prussic acid and carbon monoxide.)

PHYSIOLOGICAL ACTION OF HYDROCYANIC ACID.—It is a rapidly acting poison and produces death under asphyxial symptoms, by hindering the oxidative processes of the tissues. It is also a general protoplasmic poison. Inhalation of hydrocyanic acid in dilute concentration causes an unpleasant metallic taste in the mouth, faintness and dizziness, constriction and dryness of the throat, gasping for breath, headache, convulsions, unconsciousness, and even death. With higher concentrations the patient may fall unconscious, often with a loud cry, and die within a few minutes with or without convulsions.

FIRST-AID TREATMENT.—Remove patient to fresh air and give artificial respiration immediately. The rescue breathing apparatus should be used if available.

PHYSIOLOGICAL ACTION OF CARBON MONOXIDE.—This gas is not employed as a war gas but is of considerable importance through its occurrence in the combustion of gunpowder. It is found with the nitrous oxides in the fumes of burning powder. The explosion of a large bomb or shell in a compartment may result in a high concentration of this gas. Serious casualties may occur among those entering the compartment. The Navy gas mask does not protect against this gas, unless a special cannister is used. The oxygen-breathing rescue apparatus should be worn by those entering such a compartment.

This gas is colorless, odorless, and tasteless, lighter than air, and diffuses rapidly in the open air, so that there is no warning of its presence.

Probably the first symptoms noted in a case of moderate severity are dizziness, languor, headache, and weakness. Where the intoxication is more severe there is loss of consciousness, vomiting, convulsions, and cessation of respiration. This gas forms a firm compound with hæmoglobin thereby preventing it from carrying oxygen, with resulting asphyxia. The skin and lips are often bright red due to the color of carbhæmoglobin. Death sometimes occurs abruptly through aspiration of vomited matter during unconsciousness.

FIRST-AID TREATMENT.—Remove patient from contaminated atmosphere. Clear respiratory passages, if necessary, of vomited material and secretions. If available the rescue breathing apparatus for oxygen and carbon dioxide administration should be used. Give artificial respiration by the Schaefer method. Do

not attempt to give liquids by mouth until patient is fully conscious. Watch for possible relapse.

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Section 5.—DIVING AND SUBMARINE DUTY

The submarine service consists of submarine tenders, submarine salvage vessels, submarines, and submarine bases. Hospital corpsmen are assigned to duty independent of medical officers aboard salvage vessels and the larger submarines. They should therefore be familiar with the section of this volume dealing with independent duty.

A great deal of diving is done from aboard salvage vessels, and hospital corpsmen assigned to duty aboard these vessels are usually qualified as divers, first class, after having completed the prescribed course at the Diving School, Navy Yard, Washington, D. C. They should therefore be thoroughly familiar with the physics and physiology of deep diving, and with the treatment of compressed-air illness. Detailed information on diving is given in the Diving Manual issued by the Bureau of Construction and Repair.

Hospital corpsmen assigned to duty aboard submarines should read carefully the Bureau of Construction and Repair pamphlet "Submarine Safety—Respiration and Rescue Devices," and they should become familiar with the methods of submarine escape with the submarine "lung." This is essential in view of the fact that all personnel assigned to duty aboard submarines are required to qualify annually in the use of the "lung" by simulating escape from a depth of at least 18 feet.

"Lung" training tanks are located at the submarine bases at New London, Conn., and Pearl Harbor, T. H.

SUBMARINE VENTILATION

Contrary to popular belief, the crew of a submarine is subjected to no increased atmospheric pressure when the submarine dives. The true hull receives the pressure. Occasionally, due to compressed air leaks, there is a slightly greater barometric pressure present, but this is noted only by observing the barometer or by a crackling sound in the ears as the pressure becomes equalized on the two sides of the ear drums.

While running on the surface in a calm sea, the ventilation scheme of a submarine is, in general, comparable to that of any surface ship. Natural ventilation through hatches, which may be left open, is of tremendous assistance in improving the habitability of the ship. This method is employed in conjunction with the use of compartment electric fans to impart motion to the air, and is aided by the hull ventilation system. The hull ventilation system consists of an exhaust blower in the motor room, the farthest compartment aft, which takes the air from that compartment and forces it through a large-diameter air line forward over the pressure hull and beneath the superstructure deck above to the torpedo room, the most forward compartment. It is drawn in by a supply blower and distributed by ducts and louvers to the various compartments. The hull ventilation system is of most value during submerged runs. In that

condition the ventilation line running beneath the superstructure decking and over the pressure hull is surrounded by sea water, and the contained air is not only cooled but moisture is taken out of the air.

For obvious reasons it is not always possible to keep all hatches open on surface runs. It is usually necessary to close the torpedo room hatch and the access hatch just forward of the conning tower, to prevent seas being shipped. It may also be necessary to close the engine-room and motor-room hatches. Air for the Diesel engines is then taken through the conning-tower hatch and through the main induction system, primarily designed to take in air at a point high up near the periscopes and deliver it to the engines.

Under the latter condition there is a considerable throbbing, to-and-fro movement of the air noticeable in the ears. It is of prime importance that the water-tight door leading from the control room (beneath the conning tower) to the engine room be kept open while the engines are running. If it should, by accident or carelessness, become closed a partial vacuum will be produced in the engine room in a short period of time, with serious effects on the engine-room personnel if the engines are not stopped immediately.

During submerged runs all hatches and the main air-induction system are, of course, closed. Ventilation is then by the hull ventilation system and by electric fans in the various compartments. The air contained is simply agitated and moved about in the ship, as there is no communication with the outside. Under these conditions the temperature rises and the humidity is quite likely to become excessive. Indeed, most of the discomfort experienced by the crew is due to these changed physical properties of the air. The later types of submarines are equipped with air conditioning plants which are designed to reduce the dry bulb temperature and to decrease the humidity by mechanical refrigeration. The excess moisture removed from the air in the cooler is drained into the vessel's sanitary tanks.

Hospital corpsmen are often called upon to make observations of air conditions aboard submarines. Therefore, they should be familiar with the essential states of atmosphere and the means of control employed.

Katathermometer.

This is an alcohol thermometer with a cylindrical bulb about 4 cm. long and 2 cm. in diameter. It has a stem 20 cm. in length on which are two graduations, one corresponding to a temperature of 100° F. and the other to 95° F. When using the instrument, the bulb is warmed to a temperature well above 100° F. by means of a flask of hot water, and the bulb is then dried. The time required for the thermometer to cool from 100° F. to 95° F. is determined by a stop watch. Unavoidable differences in their size and conformation are corrected by a factor which is inscribed on each instrument. If the number of seconds required for the instrument to cool from 100° F. to 95° F. is divided into the factor, the so-called cooling power of the air is ascertained. It has been found that for persons engaged in light occupations, the cooling power of the air should attain a value of 6 or more, but may not unreasonably fall as low as 5.

The calculation of the air velocity from the observed cooling power can be made by means of a chart furnished with each instrument. Thus, if the factor is 460 and the instrument cools in 160 seconds, the cooling power is 2.9 (nearly), and if the air temperature is 84° F., a line B taken from 2.9 on H through 84° F., on the air temperature scale will indicate an air velocity of 45 feet per minute.

If the temperature of the atmosphere exceeds 90° F., the kata cooling rate will be too slow to record. The high temperature kata should then be used to obtain the air velocity, though its cooling power is not a measure of comfort. It can also be advantageously used for temperatures which approach 90° F. The high temperature kata cools from 130° to 125° F. Thus, if the factor of a high temperature kata is 410 and the instrument cools in 45 seconds, the cooling power is 9.2 and if the air temperature is 84° F., a line C taken from 9.2 on H through 84° on the *high temperature kata scale* will indicate an air velocity of 45 feet per minute.

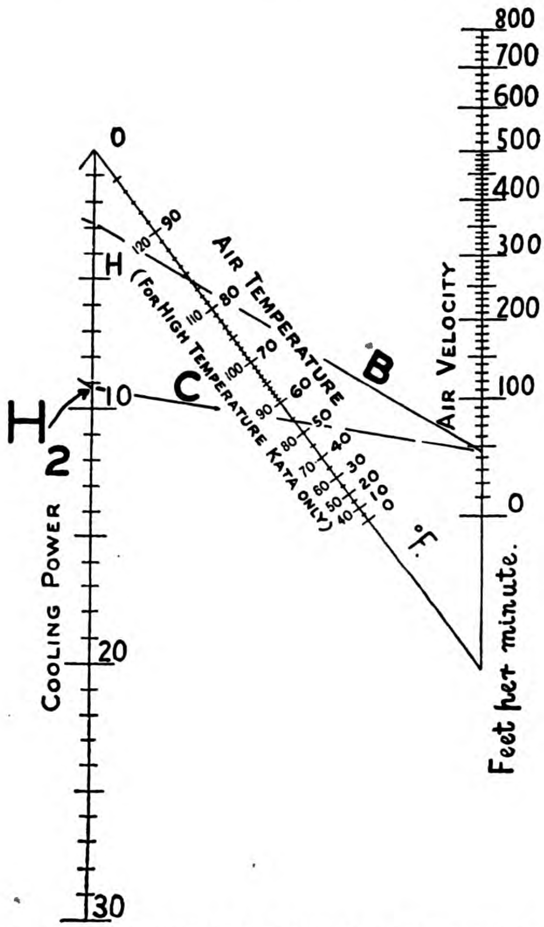


FIGURE 163.—Chart for determining kata cooling power and air velocity.

Effective temperature.

The numerical value of the effective temperature for any given air condition is fixed by the temperature of saturated air which at a velocity of 15 to 25 feet per minute induces a sensation of warmth or cold like that of the given condition. Given the dry bulb temperature and the velocity of air motion, the effective temperature may be determined from the thermometric chart.

Say the dry bulb temperature is 76, the wet bulb temperature is 62, and the velocity of air is 100 feet per minute, the point where the line drawn through the wet and dry bulb temperature intersects the 100 feet per minute curve gives 69° for the effective temperature. For optimum comfort, the effective temperature should be between 66° and 71°, and the relative humidity should be between 30 and 70 per cent.

It is important that when the sling psychrometer is used for determining the wet bulb temperature, the revolutions be as rapid as possible. It is usual to take temperature at 5 feet above the floor level, or what is termed the breathing line.

Hydrogen.

Separate and distinct from previously mentioned arrangements is the battery ventilation system. As nearly everyone has observed, an electric storage battery gives off bubbles of gas constantly, mainly during the taking of a charge and particularly toward the end of a charge. This gas is hydrogen, a highly inflammable gas. When hydrogen is burned, two parts of this gas unite with one part of oxygen to form water. Considerable heat is produced. This gas is the most diffusible of all gases and passes through the meshes of the

Davy safety mining lamp, which prevents the production of explosions in mines. An air mixture containing 4.1 per cent of hydrogen is considered inflammable and 8 per cent is explosive. Instructions for the care and ventilation of batteries are aimed to keep the hydrogen in the battery cells and ventilation ducts below 2 per cent, and it is usually well within these limits. Each battery compartment contains a Hydrogen Detector for determining the percentage of hydrogen in the air of the system. Full details regarding the operation of this instrument are given in the Bureau of Construction and Repair Manual. Dangerous amounts are occasionally discovered in making an air analysis or they may be announced emphatically by a battery explosion.

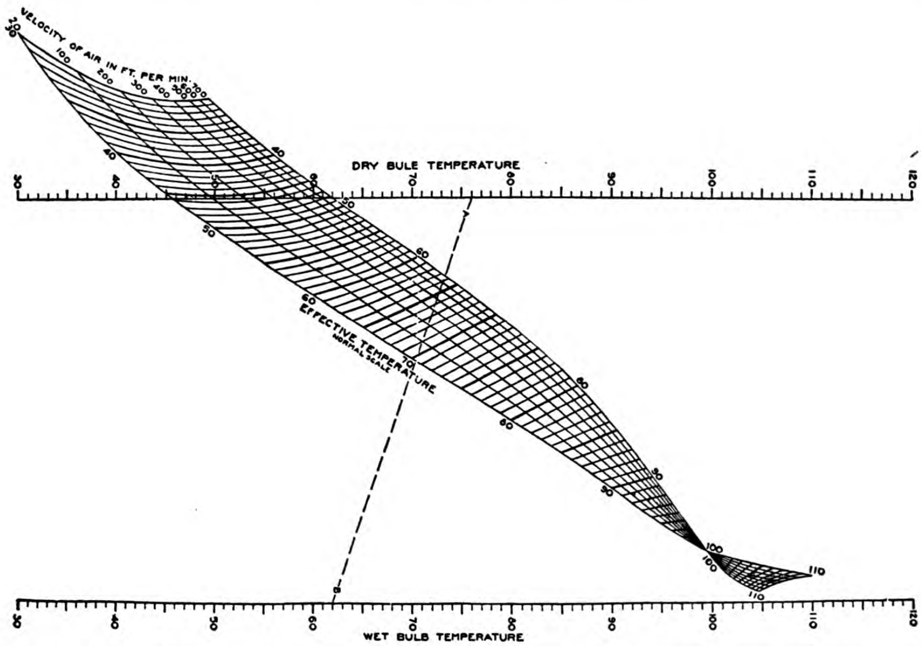


FIGURE 164.—Thermometric chart showing scale of effective temperature.

The battery ventilation system of ducts and blowers can be made to discharge the battery gas overboard during surface runs or inboard during submerged runs. While hydrogen itself is odorless, a more or less strong acid odor is noted coming from the battery ducts during a submerged run. This is due to a minute envelope of sulfuric acid surrounding the hydrogen bubbles which come off from the battery cells. The blowers suck up some of the minute droplets and distribute them into the air of the battery compartment. This produces at times an unpleasant odor, often mistaken for chlorine.

Chlorine.

This gas is two and one half times heavier than air and remains close to the deck unless distributed by air currents. It is highly toxic, causing coughing when present in a concentration of 1 part in a million, dangerous if breathed in concentration of 10 parts per million for half an hour, and very dangerous in concentrations of 100 parts per million if breathed for a few minutes. This gas is produced in a submarine when sea water gets into a battery cell. The gas masks issued to submarine personnel protect against chlorine in the concentrations which may occur as a result of sea water accidentally getting into the battery cells. The canister of the submarine

mask for protection against chlorine contains in addition to soda lime, Whetlerite (activated charcoal impregnated with copper sulfate). The submarine "lungs" are now so designed that by the insertion of an appropriate canister they serve the purpose of a gas mask.

Carbon monoxide.

This gas results from the incomplete combustion of any kind of fuel and is a constituent of the exhaust gases of engines. It is also found after fires in closed compartments where there is an insufficient supply of oxygen. The gas, even if present in concentrations of 1 part in 10,000, combines with the blood to form a stable compound which will no longer carry oxygen to the tissues. Carbon monoxide is particularly dangerous because it is odorless, and those exposed to it are often unaware of any ill effects until they collapse. The canister of the submarine gas mask for protection against carbon monoxide contains Hopcolite, which converts carbon monoxide to carbon dioxide. It is necessary to keep these respirators free from moisture in tightly sealed containers.

Carbon dioxide.

There is only 0.03 per cent of carbon dioxide in pure atmospheric air. When the proportion of carbon dioxide rises to 3 per cent the rate of breathing begins to be noticeably increased; with 6 per cent carbon dioxide there is quite severe panting, and when more than 10 per cent carbon dioxide is breathed, the effect is to produce stupefaction. This effect is very marked with higher percentages, and it is interesting to note that carbon dioxide was one of the gases tried as an anæsthetic by Sir James Simpson before he adopted chloroform.

Under conditions of bodily activity comparable to that aboard submarines, each man produces about 0.75 cubic foot of carbon dioxide an hour. The instructions for air purification aboard submarines are designed to limit the concentration of carbon dioxide so that it will not exceed 3 per cent. As the contained air in a submarine at the outset of a dive is pure, it will not reach the limiting value of 3 per cent carbon dioxide in any compartment until the expiration of x hours, which may be calculated from the formula

$$\frac{3\times\text{capacity in cubic feet}}{0.75\times100\times\text{No. of men}}.$$

When C is substituted for capacity in cubic feet and N for number of men, balancing this formula gives $0.04\times\frac{C}{N}=x$ hours when carbon dioxide will rise to 3 per cent. The capacity in cubic feet of different types of submarines is given in the Bureau of Construction and Repair Manual.

Higgins-Marriott Carbon Dioxide Testing Outfits are supplied for determining the percentage of carbon dioxide. This consists of a rack of four standard tubes indicating 1 per cent, 2 per cent, 3 per cent, and 4 per cent carbon dioxide. A sample of air bubbled through a solution of sodium bicarbonate containing an indicator is matched with the standard tubes, and the percentage of carbon dioxide is thus read off. Complete instructions for operating the Higgins-Marriott instrument are given in the Bureau of Construction and Repair Manual.

Air at normal atmospheric pressure containing as high as 3 per cent carbon dioxide can be breathed for short periods without danger. When the atmospheric pressure is abnormal, however, the physiological effects of carbon dioxide and other gases in the air breathed depend on their partial pressure. It is

only when the barometric pressure is constant that their actions depend on their percentage proportion. The method of calculating the partial pressure of carbon dioxide may be illustrated by an example. Let it be supposed that the barometric pressure is 760 mm (one atmosphere) and that 3 per cent carbon dioxide is found in the air. Of this pressure, then, 3 per cent is due to carbon dioxide. Hence, the pressure of carbon dioxide is $3 \times \frac{760}{100} = 22.8$ mm. or 3 per cent of an atmosphere, as 22.8 is 3 per cent of 760. Every 33 feet of sea water represents an atmosphere of excess pressure. Therefore, if a submarine escape compartment containing 3 per cent carbon dioxide is flooded to equalize the pressure of the outside sea water at a depth of 66 feet or 3 absolute atmospheres, the partial pressure of carbon dioxide will be increased threefold, and the physiological effect will be equivalent to that of air containing 9 per cent carbon dioxide. Prior to a flooding process, therefore, it is advisable to rapidly remove any excess carbon dioxide that may be present in an escape compartment.

The Navy Standard carbon dioxide absorbent has been developed especially for air purification aboard submarines. One tenth of a pound will absorb 0.75 cubic feet of carbon dioxide, the amount given off per man per hour. It is thus about 5 times more efficient than soda lime. It absorbs carbon dioxide by contact. Full instructions regarding the application of this chemical aboard submarines are found in the Bureau of Construction and Repair Manual.

Oxygen.

Pure atmospheric air contains 20.93 per cent oxygen. Just as in the case of carbon dioxide, the physiological action of oxygen in the air breathed depends on its partial pressure. The effects of a low percentage or decreased partial pressure of oxygen are well known. They are encountered among aviators, mountain climbers, and men who have been poisoned by carbon monoxide from illuminating gas or from the products of incomplete combustion in fires in closed spaces. If a person be exposed to an atmosphere in which the amount of oxygen is diminishing slowly, he gradually becomes acclimated by means of a physiological adaption of his blood circulation and respiration to the new conditions. On the other hand, men exposed to a rather sudden diminution in oxygen will show symptoms of mountain sickness, such as weakness, dizziness, blue color, rapid respiration, nausea, and finally collapse. Such symptoms are rarely ever encountered in a submarine—certainly not under normal operating conditions, because air purification is carried out long before the onset of these signs. These symptoms can be relieved by a return to air richer in oxygen or by the administration of oxygen from a cylinder.

At present there is no oxygen test applicable for use in submarines simpler than the Orsatt. This apparatus is too fragile for routine issue to submarines. For practical purposes a lighted candle usually indicates air which contains sufficient oxygen for a man to breathe safely. But man and candle are profoundly different. The candle becomes extinguished when the oxygen falls to 15 or 16 per cent, or about 114 mm. partial pressure, equivalent to the oxygen pressure at an altitude of 5,500 feet above sea level, approximately that of Denver, Colo, where people live healthy lives and candles burn normally because the atmospheric air contains 20.93 per cent oxygen. On the other hand, an atmosphere containing 5 per cent oxygen and compressed to 4 atmospheres pressure (the partial pressure of oxygen will then be nearly normal), will maintain a man perfectly in respect to oxygen, but a candle cannot be lighted.

It is found that with the production of 0.75 cubic foot of carbon dioxide per man per hour each man consumes about 0.9 cubic foot of oxygen per hour.

It is not desirable for the oxygen to fall below about 17 per cent. Therefore, the formula for calculating x hours for limiting the value of 3 per cent carbon dioxide gives the approximate expiration of x hours for the contained air in the submerged vessel to reach 17 per cent oxygen. Hence, the instructions for air purification call for bleeding into the vessel 0.9 cubic foot of oxygen per man per hour when the carbon dioxide absorbent is required to be used. As normal atmospheric pressure corresponds to 14.7 pounds per square inch, the approximate quantity of oxygen desired is obtained by allowing the gauge pressure in the cylinder to drop in pounds per man equal to 0.9×14.7 divided by the net capacity of the cylinder in cubic feet. Thus, if the volume of the oxygen cylinder is 1.53 cubic feet and there is a crew of 43 men, oxygen is released until the gauge pressure drops $\frac{13.23}{1.53} \times 43 = 372$ pounds. A new type of outlet valve is now being installed, so that if the hand on the metering gauge is set for the number of men for whom oxygen is being supplied, about 0.9 cubic foot of oxygen per man is released.

Oxygen at high partial pressure is well known to be toxic. It is desirable, therefore, to avoid any great increase in the percentage of oxygen above normal prior to a flooding process in an escape compartment, since the partial pressure of oxygen will increase in the same manner as considered in the discussion of carbon dioxide.

On the other hand, if the oxygen percentage of the atmosphere is much below normal at the time of the flooding process, the percentage proportion of nitrogen will be increased, and the partial pressure of nitrogen will be correspondingly increased, and susceptibility to compressed air illness may be increased.

Nitrogen.

Normal atmospheric air contains about 79 per cent nitrogen. During the flooding of a compartment for "lung" escape, the air is compressed to a pressure corresponding to that of the depth of the water in which the submarine is submerged. This becomes necessary in order to open the escape hatch. In compressed air the blood reaching the lung capillaries becomes instantly saturated with nitrogen at the partial pressure existing in the air. The amount of nitrogen which thus goes into solution in the blood is directly proportional to the pressure. Thus at three atmospheres (corresponding to a pressure of 66 feet of sea water) thrice as much nitrogen will be taken up by the blood as is taken up at normal atmospheric pressure. During exposure to compressed air, the blood carried to the tissues will, by diffusion, share with them its excess of nitrogen, and the tissues will gradually become more and more saturated with nitrogen at the partial pressure of nitrogen in the inspired air.

The symptoms of compressed air illness are due to the fact that gas, chiefly nitrogen, which goes into solution in the blood and tissues during exposure to compressed air, is liberated as bubbles on too rapid air decompression. It is well known, however, that the blood and tissues of the body can hold gas for long periods in a state of supersaturation, provided the supersaturation does not exceed a certain limit. No symptoms occur with less than 1.25 atmospheres of excess pressure (42 feet of sea water), no matter how long the period of exposure may be. The frequency and gravity of symptoms increase rapidly with higher pressures unless the time of exposure is limited or slow decompression is resorted to. Therefore, after the pressure has been raised in the escape compartment, if the period of exposure is prolonged, the ascent with the "lung" may require a certain amount of decompression in order to

avoid symptoms of compressed air illness. If possible, decompression in the recompression chamber of a salvage vessel would expedite escape. The decompression tables for various depths and periods of exposure are given in the Diving Manual.

Air embolism.

As the volume of air is directly proportional to the pressure, the volume of air in a man's lungs will undoubtedly expand during ascent with the submarine "lung", unless breathing is continued at the normal rate. To hold the breath during ascent with the "lung" is very dangerous, because the increased pressure built up in the lungs by the expansion of air may rupture the lung capillaries and thus cause air embolism. For this reason, men are enjoined to ascend the line at a rate no faster than 50 feet per minute. and to continue breathing at the normal rate.

Section 6.—ELECTROCARDIOGRAPHY

Electrocardiography is one of the most important methods of cardio-vascular examination, ranking in value third after history taking and physical examination.

Kölliker and Müller in 1856 demonstrated that when a frog's heart contracted it produced an electric current. Then in 1887 Waller showed that the human heart current could be demonstrated by connecting the outside of the body by electrodes with the capillary electrometer. However, this mercury capillary electrometer was not sufficiently accurate for practical clinical use, although it was being used in the laboratories by physiologists. Finally in 1903 came the announcement of the discovery of the accurate and practical string galvanometer by Einthoven, a Dutch physiologist.

Electrocardiographs have been installed in hospitals and examining rooms throughout the world, and of late years, through the invention of portable instruments, it has become practical to take an electrocardiographic tracing (electrocardiogram) in the sick room whether ashore in a hospital or in a hospital ship afloat. It may well be said now that a cardiovascular examination is not complete without an electrocardiogram, which often affords much help in diagnosis. On the other hand, it must be realized that the electrocardiogram may be perfectly normal even in the presence of serious heart disease.

The instruments.

An electrocardiograph (string galvanometer type) is complex and must be personally inspected to be satisfactorily understood. The essential feature is a very fine fiber or string of quartz or glass made opaque by a coating of silver and capable of conducting electric currents. Some strings are made of finely drawn platinum. This fiber is but 2 to 5 microns in diameter, so fine in fact that it cannot be readily seen except by the use of reflected light. The fiber is suspended in the magnetic field between two poles of an electromagnet and its ends are in circuit with certain attachments or electrodes placed upon the patient. When the patient is connected with the electrocardiograph a minute electrical current passes through the string and causes it to oscillate laterally as the circular waves of electromotive force induced by the passing current coincide with or are opposed by those streaming between the poles of the electromagnet. The magnetic field remains constant but the current may pass through the string in one direction at one moment and in the reverse at another. On each side of the magnetic field is a set of lenses arranged as in

a microscope and commonly called microscopes. Through one set of lenses light from an electric lamp is directed on the opaque string, which causes it to make a shadow. This shadow is magnified about 900 times by the opposite set of lenses, which projects and focuses it on the lens of a motion camera, where it is subsequently photographed. A suitable marker is included in the instrument. An electrocardiograph is, in brief, an instrument in which a very fine fiber is suspended in a magnetic field and its oscillations induced by the electrical forces set up by the passage of the current derived from the heart beats of a patient are recorded photographically.

Oscillographic galvanometer.—This type of instrument, introduced about 12 years ago for electrocardiography, is a modification of a well known type of galvanometer much used by the engineering profession under the name of oscillograph. The modification consists of passing the heart current through a set of three electro-vacuum tubes (audion bulbs) which greatly amplifies the current. This current oscillates a mirror from which a beam of light is reflected onto a photographic surface. This instrument is sturdier, more portable, less delicate, and the technique is simpler.

Electrodes.—A common type of electrode is a sheet of German silver covered with cloth pads and wet with warm 20 per cent salt solution, or a special acid paste may be used at the point of contact with the body. Suitable wires are attached to the electrodes and thence run to the switchboard of the electrocardiograph.

The leads.—Although two electrodes may be attached to any parts of the body (if they are not too far from the heart and too close together) to lead the heart current to the galvanometer, it has been found by experience that the most suitable lead points for routine clinical use are the forearms, the left leg, and the præcordium (the area of the chest overlying the heart) at the cardiac apex. Hence there are four standard leads: Lead 1 consists of the connection of the right lower arm to one end of the galvonometer string and of the left lower arm to the other end; Lead 2 consists of the connection of the right lower arm to one end of the galvanometer string and of the left leg to the other end; Lead 3 consists of the connection of the lower left arm to one end of the galvanometer string and of the left leg to the other end; and Lead 4, also called the chest lead, consists of the connection of the præcordium at the cardiac apex to the galvanometer string by an electrode to which the left leg lead wire is attached while the left arm lead wire is attached to the electrode on the left leg and is taken on lead 3.

Technique.

While the details of the taking of an electrocardiogram are to be learned in the laboratory or heart station, a few statements, however, may properly be included in this presentation of the subject.

The patient may be lying or sitting but should be relaxed and immobile. The skin is rubbed briskly with a cloth wet with warm saline solution to reduce the resistance of the skin to the passage of the minute electrical current. The electrodes are then applied and connected with the wires to the instrument. The lead desired is selected by turning the proper key on the switchboard and the patient is put in circuit with the string while the protective resistance (supplied by the instrument) is in operation. This resistance is to protect the delicate string from the possibility of fracture by receiving too great a current from the patient's skin. If, when the key is turned (first step) the string shadow is deflected from the starting point, it is brought back by letting in sufficient compensating current (obtained by turning a certain knob on the

switchboard). This procedure is repeated to remove the protective resistance by steps and introduce enough compensating current to neutralize the skin current, until the patient is in free circuit with the string.

The next step is known as standardization. The usual standardization is that advocated by Einthoven, and is an excursion of the string shadow 1 cm. in distance on the camera in response to the throwing in of one millivolt of electric current (obtained by turning a certain knob on the switchboard). If the string shadow jumps too much or too little, the correct excursion is obtained by turning a milled screw which tightens or loosens the string as desired. The purpose of standardization is to allow comparative observations to be made upon electrocardiograms taken at different times and in different laboratories. Also, the determination of whether the excursion of individual waves is within normal limits is permissible only if the tracing has been taken under the standard method.

Having been standardized, the string shadow is then focused as sharply as possible on the front of the camera, by focusing the objective of the microscope or set of lenses nearest the camera. A photograph of suitable length is then made, and the above process repeated for the other three leads. The film or paper is then developed according to the rules of photography in general. After being dried the tracing is ready for examination.

The normal electrocardiogram.

An electrocardiogram is a photograph of the oscillations of the string of the galvanometer caused by changes in the electrical potential of the heart muscle as the contraction wave passes over the organ. At first sight the tracing looks

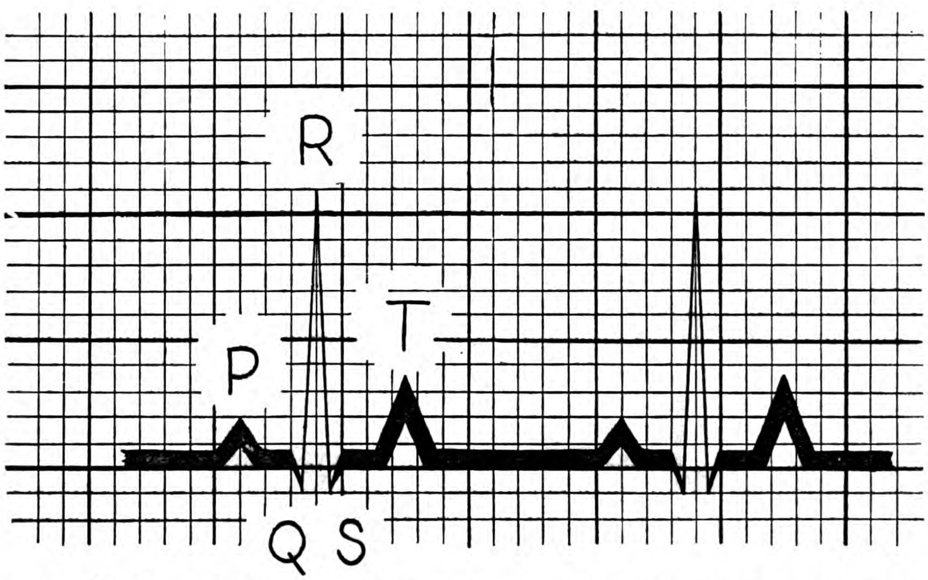


FIGURE 165.—Diagram of a normal electrocardiogram drawn to scale. Two cardiac cycles are represented. The complexes are designated by the letters P, Q, R, S, T. Vertical lines in background of diagram represent time. Heavy lines = one-fifth second; fine lines = one twenty-fifth second. Horizontal lines designate height of waves in millimeters.

like a zigzag line, but on closer inspection it can be seen that the departures from the base line are of several types which are repeated in regular order. These deflections are called waves. They were originally labelled in an arbitrary manner (before their significance was known) as the P, Q, R, S, T, and

U waves. The use of these letters to designate the individual waves has become an established practice.

The waves are termed upright or inverted according as they are above or below the base line. It is also a common practice to refer to upright waves as positive and inverted ones as negative.

The P wave is the record of auricular systole.

The QRS complex is associated with the initial spread of the contraction through the specialized tissue in the ventricle.

The T wave is known as the end deflection of the ventricular complex. It is associated with the retreat of the contraction after its spread in the ventricle.

The U wave is a small upright wave sometimes found immediately subsequent to the T deflection. It is more often present in slow beating hearts, is of uncertain origin, and is considered unimportant.

Figure 165 shows a diagrammatic normal electrocardiogram.

Section 7.—EMBALMING

Embalming is the art of preserving bodies after death and is an art which has been practiced for many centuries. Preservation of the dead was regarded as a religious duty by the ancient Egyptians who carried the art of embalming to a high degree of perfection. That Egyptian embalming was effective has been proved by the discovery of mummies in excellent states of preservation after the passage of centuries, in one instance about 25.

The Egyptians used three methods of embalming, and from the description of those methods, as reported by the Greek historians Herodotus and Diodorus, it is apparent that the principles of modern embalming are much the same as those of ancient times.

All members of the Hospital Corps should be familiar with the procedures employed in embalming the bodies of the dead and with preparing the remains for interment and for shipment. Embalming only will be discussed in this section and reference should be made to Articles 908, 1513, and 1841, U. S. Navy Regulations, and to Chapter 19, Manual of the Medical Department, U. S. Navy, for full information regarding deaths and the care of the dead. Reference also should be made to the section on Deaths and Medicolegal Matters in chapter XI of this book.

All bodies prepared for interment or shipment under the supervision of naval medical officers are thoroughly and completely embalmed in the manner described hereafter, using the embalming fluid as prescribed. If the embalming is done in the United States by a licensed embalmer he may be permitted to use the standard embalming fluid with which he is familiar.

It is incumbent on all Navy embalmers to exercise great care in the preservation of bodies and their preparation for the casket, so that they may reach relatives showing evidence of respectful and careful handling, without signs of decomposition, and with the so-called natural appearance preserved.

Shaving and modeling of the features should be completed before beginning the injection. The face and hands should be liberally anointed and carefully massaged with an ointment made of vaseline in which 10 per cent each of eugenol and thymol are thoroughly incorporated. This ointment prevents drying and tends to prevent the growth of molds on exposed skin, an important matter in regard to preserving the natural appearance of the face and hands. Any excess ointment should be removed and care should be exercised in its use, as it is very irritating to living skin and may be escharotic.

Although recommended as tending to produce a more pleasing appearance of the body and as lessening the liability to development of discolored spots and localized collections of gas, it is not necessary to drain the veins of contained blood. It is well, however, to emphasize the fact that draining the maximum amount of fluid from a body facilitates penetration of the embalming fluid, and the more the veins are drained the better the penetration obtained.

Embalming, to be satisfactory, requires both arterial and cavity injection.

Arterial injection.

(*a*) The arterial system shall be injected with an amount of the prescribed embalming fluid equal to 15 per cent of the body weight, estimating 450 cc of fluid as 1 pound. (Fig. 166.)

Inject each femoral artery toward toes with 2 per cent body weight.

Inject each brachial artery toward fingers with 1 per cent body weight.

Inject one common carotid artery toward head with 2 per cent body weight.

Inject same common carotid artery toward heart with 7 per cent body weight.

Total amount of fluid, including both femorals and both brachials, 15 per cent body weight.

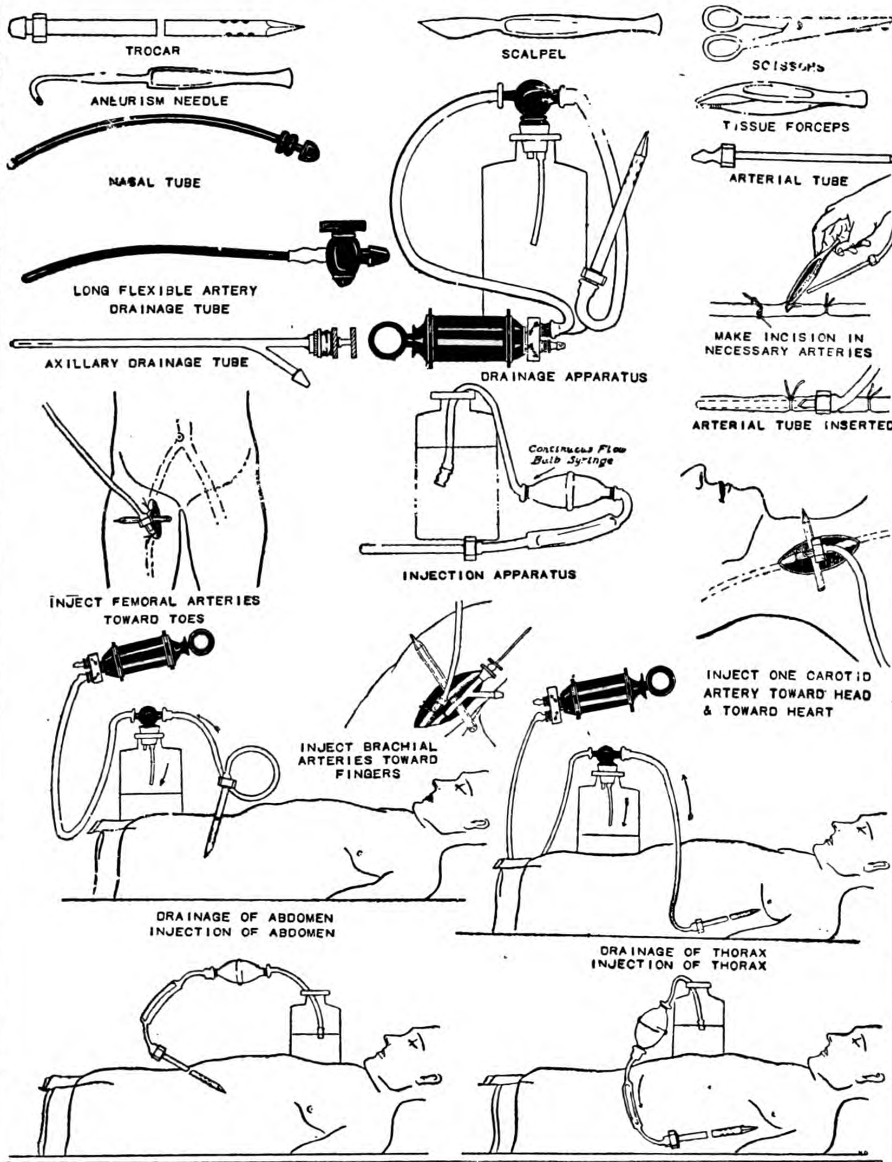
(*b*) The technique of injection is important, because prolonged preservation depends upon saturation of every tissue of the body with embalming fluid. To insure uniform distribution it is usually necessary to make all six injections. The return of fluid through the veins while the extremities are being injected will indicate saturation of the extremities, and the return of fluid during the carotid injection upward will indicate sufficient fluid has been injected into the head and upper extremities. When beginning the injection it is often advisable to first use about 200 cc of warm physiological salt solution, a 12 per cent aqueous solution of sodium sulfate or enough of a solution of 180 Gm. of magnesium sulfate dissolved in sufficient water at 85° F. to make 4,000 cc to dissolve clots and thickened blood and thereby aid in removing the blood from the veins and facilitate the flow of the embalming fluid. It is claimed that a 25 per cent aqueous solution of magnesium sulfate will completely prevent clotting of blood. Care should always be exercised to make certain that the injection is made into an artery, for if a vein, tendon, or nerve is mistaken for an artery and an attempt made to inject them, the embalming fluid escapes into the surrounding tissues, which harden and make it very difficult to proceed with the injection.

Penetration is promoted by repeated flexion and extension of limbs and by gentle but thorough massage of soft parts with vaseline or phenol ointment. Massage is the only satisfactory method of removing discoloration from soft parts. An advancing line of firmness of the tissues may be taken as an indication of the progress of the fluid. Raising the head and neck about 6 inches at the start of the injection will tend to prevent flooding of the face and to give more equal penetration.

It is an easy matter to overinject so that the face and hands are puffy and unnatural. To avoid this two signs may be accepted as indicating that sufficient fluid has been used regardless of the actual amount injected, namely: First, if the eyes, lips, or one side of the face become overdistended, or in the case of an extremity when it is apparent that the fluid has circulated from the smaller arteries through capillaries into veins; and, second, when the tissues of a region are uniformly firm, with no "soft" areas remaining.

Overinjection, however, is not objectionable if a long time is to elapse before the remains are to be viewed, because a slow shrinkage of the body usually takes place.

THE NAVY STANDARD EMBALMING OUTFIT



Rx		
	LIQUID FORMALDEHYDE	13.5 C.C.
	BORAX (SODIUM BORATE)	5.0 GMS.
	GLYCERIN (OPTIONAL)	5.0 C.C.
	WATER, SUFFICIENT TO MAKE	100.0 C.C.

AMOUNT OF FLUID TO USE 15 % OF BODY WEIGHT.
2 % IN EACH FEMORAL ARTERY.
1 % IN EACH BRACHIAL ARTERY.
2 % IN ONE CAROTID ARTERY TOWARD HEAD.
7 % IN SAME CAROTID ARTERY TOWARD HEART.
INJECT THORAX UNTIL SLIGHT EPIGASTRIC FULLNESS IS APPARENT.
INJECT ABDOMEN UNTIL SLIGHT DISTENTION IS APPARENT.

1. PREPARE EMBALMING FLUID
2. ASSEMBLE OUTFIT FOR USE
3. INJECT FEMORAL ARTERIES TOWARD TOES.
4. INJECT BRACHIAL ARTERIES TOWARD FINGERS.
5. INJECT ONE CAROTID ARTERY TOWARD HEAD AND TOWARD HEART.
6. DRAIN AND INJECT THORAX.
7. DRAIN AND INJECT ABDOMEN.
8. TIE UP ARTERIES AND SEW UP INCISIONS IN SKIN.

FIGURE 166.

(c) When the carotids are being injected, massage of the face and adjacent parts is important, it being especially necessary to make sure that the fluid reaches less vascular parts, such as the tip of the nose and margins of the ears. Here, as elsewhere, palpable firmness of the tissues is the indication of successful injection. If any of these parts remain soft after completion of the arterial injection and show signs of "skin slipping," fluid should be introduced by means of a hypodermic syringe, the point of the needle being inserted through the ear, hair line, nostril, or mouth, so that the puncture will not be noticeable.

When, as sometimes happens, it is impossible to attain uniform firmness at the first injection, a second injection undertaken the next day often reaches the soft areas.

Cavity injection.

Besides injection of the arterial system, cavity injection should be performed, as much additional fluid being used for this purpose as may be required. When circumstances permit delay, it is well to postpone cavity injection until several hours have elapsed after the arterial injection has been completed. By that time, if a second arterial injection is to be required, the necessity for it will be apparent, and it can be undertaken before the breaks in the arterial system resulting from cavity injection are made.

(*a*) *Thorax.*—By means of aspiration at several points remove all body fluids and inject each pleural cavity with embalming fluid under moderate pressure until a slight epigastric fullness becomes apparent.

(*b*) *Abdomen.*—By means of aspiration, the point of the needle being extensively moved about, remove as far as possible all gas, liquid intestinal contents, and pathological fluids. Then inject embalming fluid, again moving the needle point about extensively, until slight distention is apparent. Kneading of the abdomen favors diffusion of the fluid.

General instructions.

(*a*) After autopsy bodies are to be embalmed in the same way; but in such cases the cavities of the abdomen, chest, and skull, after complete removal of all viscera, shall be packed with absorbent cotton saturated with embalming fluid, or a hardening compound composed of equal parts by weight of flake camphor or naphthalene, plaster of Paris, and dry sawdust may be used. Especial care must be exercised that the evidences of autopsy shall not cause unnecessary distress to relatives. To that end all wounds that have been made shall be neatly closed, if the brain has been examined the skullcap shall be secured to prevent its slipping, and packings and dressings used shall be clean and of suitable material.

(*b*) If fluid cannot be forced into an artery because of clots or other reasons, such as mutilation or advanced decomposition, multiple injections may be made into the tissues, which then should be wrapped in cotton saturated in embalming fluid. In such case, further, the anus, mouth, and nostrils should be plugged with cotton soaked in embalming fluid, and the entire body, including the face, ears, and hair, washed with the fluid.

(*c*) In the case of a body dead of smallpox, plague, Asiatic cholera, typhus fever, diphtheria, or scarlet fever, the remains, after being washed and after completion of the embalming, shall be bandaged completely, excepting the head, with muslin soaked in embalming fluid. The hands and face shall be enveloped in a suitable cloth saturated with embalming fluid. The laws of some States require that in such cases all body orifices be plugged with cotton soaked in 1–500 solution of mercury bichloride and the body wrapped in cloths saturated with 1–1,000 solution of mercury bichloride.

Embalming fluid.

(*a*) The formula for the embalming fluid to be used is given herewith.

Liquid formaldehyde (U. S. P. solution of formaldehyde)	cc	13.5
Sodium borate (borax)	grams	5.0
Glycerin (optional)	cc	5.0
Water, sufficient to make	cc	100.0

Should the solution of formaldehyde contain less than 37 per cent of formaldehyde gas, the amount used should be increased proportionately.

The addition of ethyl alcohol in the proportion of 10 per cent of the amount of the liquids in this formula aids in the solution of the sodium borate and to some extent in preventing "graying" of the skin.

(*b*) As this solution is irritating to many skins, some form of protection is advisable. Gloves may be worn in special cases, but in general it will be found more convenient and equally safe to anoint the hands prior to beginning work with a heavy protective ointment.

(*c*) The exact composition of an embalming fluid is of less importance than the method of injecting it, but service embalmers, who may be acquainted with civilian practice and inclined to follow it, should remember that methods which have proved equal to preserving remains for a few days in temperate regions may be entirely inadequate to preserve bodies for months in the tropics. The fluid represented by the formula quoted (Francis) will retain its stability for more than 2½ years; it has proved effective in preserving human subjects exposed for 2 months to a temperature of 98° F.; and the property of formaldehyde in acid solution of bleaching muscular tissue to an ashy gray is overcome by the addition of borax, which furnishes the desired alkalinity without causing deterioration of the solution. This formula is to be used, therefore, in all cases.

(*d*) The fluid hardens tissues so rapidly that thorough penetration to more remote parts often is hindered. For this reason the whole procedure should be carried out expeditiously, and it is recommended that at each site specified the injection be started with half-strength solution; when the return flow is established the full-strength solution then should be used as directed in this section.

(*e*) The pressure essential to successful injection may be obtained either by elevating the container to a height of 6 feet or, in emergency, by means of a continuous flow rubber bulb syringe or a hard rubber pump syringe. The details requiring attention in employing either method will suggest themselves. It is necessary to state that if a pump is used, in order to avoid rupturing blood vessels, the pumping *must be slow* and no attempt made to force or hurry the flow of the embalming fluid. A slow penetration by gravity with a minimum of pressure gives better results and preserves the natural appearance much better.

When an embalmed body is to be returned from foreign countries to the United States or must be retained on board ship for some time, especial care must be exercised to insure that it will be in good condition at the time of shipment and interment. To accomplish this an injection of one-fourth strength embalming fluid may first be made, followed 12 hours later by one-half strength and 36 hours after the first injection by one of full strength. In such cases the body should not be encased until sufficient time has elapsed after embalming for thorough evaporation of moisture to take place. After time for evaporation has been allowed, the entire body should be coated with vaseline or phenol ointment and wrapped, first with gauze, muslin, or surveyed linen and then with impervious waxed paper, the wrappings being secured in place by bandages. Before encasing the wrapped but unclothed body the casket should

be opened and exposed to the sun or artificial heat in order that the lining and padding may be free from moisture. Clothing for the body should be dried, wrapped in impervious waxed paper, and placed on top of the casket in the shipping box.

REFERENCES

Manual of the Medical Department, U. S. Navy.
Bureau of Medicine and Surgery circular letters.

Section 8.—INDEPENDENT DUTY

To carry out the duties with which it is charged in articles 457 and 458, Navy Regulations, the Bureau of Medicine and Surgery assigns chief pharmacist's mates and pharmacist's mates, first class, to duty as the representatives of the medical department on board small vessels and at small shore stations where the nature of the duty does not justify the assignment of medical officers. They are not offered as substitutes for qualified medical officers, but rather as first-aid men who are capable of relieving the commanding officer of most, if not all, of the detailed management of the sick and injured. Because of the training, instruction, and experience of men in the Hospital Corps, especially in the upper ratings, the Bureau of Medicine and Surgery believes that many times life or limb may be saved that might, without their intelligent first-aid, be jeopardized.

The responsibilities of pharmacist's mates on independent duty are similar to those of a medical officer, and the mission is the same. Pharmacist's mates assigned to independent duty have demonstrated their qualifications for their rating by written and practical examinations and the Bureau of Medicine and Surgery feels that the commanding officers of vessels and shore stations to which no medical officer is attached, whose experience, general education, judgment, and mental training especially fit them for the assumption of responsibility in emergencies, ordinarily may rely on these men for valuable and trained assistance in first-aid work when more skilled medical services cannot be secured.

Pharmacist's mates assigned to duty independent of a medical officer and where medical officers are not available are cautioned to bear in mind the fact that the commanding officer of the ship or station is directly responsible for the proper care and disposition of the sick and injured. But it is a paramount duty of a hospital corpsman so situated to make recommendations to the commanding officer regarding matters affecting the health of the crew, the disposition of the injured, or any unusual condition requiring the services of a medical officer or qualified medical practitioner, temporary assistance for members of the crew, etc.

There should be a definite time, approved by the commanding officer for sick call. Minor ailments and injuries are attended to at this time; arrangements for vaccination, visiting a medical officer, and excusing men from duty, but at any time the pharmacist's mate should be ready to examine men who could not attend regular sick call or who have become ill or have been injured subsequently.

Second only to the care of those actually sick or injured is the responsibility of independent-duty pharmacist's mates with regard to the application of hygienic and sanitary measures. A daily inspection of the ship or station is necessary to accomplish this, and should not be made until after all cleaning stations have been policed.

In making this daily inspection particular attention should be given to places where dirt can accumulate, such as corners, angle-irons, mess gear, mess and clothes lockers, fans, ventilators, blowers, ice boxes, vegetable lockers, wash bowls, urinals, drains, scuppers, and gratings—in fact, any place where an effort must be made to attain cleanliness. The condition of the cooking utensils, pots and pans, the galley range and the deck beneath it should be observed; the bottoms of mess tables and bunks, especially the bunk frames, should be inspected; in storerooms the stowage of unauthorized articles, such as wash buckets, swabs, dirty or wet clothes, should not be permitted, and one should be sure that the bilges of storerooms aboard ship are dry and clean. Ashore, in addition to the above, care must be exercised in the disposal of waste and garbage, the accumulation of stagnant water, drainage, protection of water containers, removal of undergrowth, manure, leaves, etc., cutting weeds and long grass, and the methods used in the disposal of human excreta.

In short, it is most important that the pharmacist's mate on independent duty constantly be on the alert to observe anything and everything that in any way might be detrimental to the health and welfare of those with whom he is serving and who depend upon him for protection against disease. Dirt, filth, grease, and decayed or decaying matter are dangerous to health; all can be removed by the use of water, soap, kerosene, and "elbow grease"; and all can be prevented by careful observation and frequent inspection.

In the absence of medical officers it devolves upon the pharmacist's mate representing the medical department to inspect the food prepared for the crew, as to wholesomeness and cleanliness, the fruit and other articles of food and drink offered for sale by boats alongside, and all fresh provisions purchased for the general mess. After such inspections a report should be made to the proper officer as to the conditions found, with such recommendations as are considered necessary. There should be no hesitancy in recommending rejection or refusal of permission to boats alongside to sell if the inspection shows them to be unsatisfactory. Instructions governing such inspections are contained in articles 1156, 1157, 1158, 1159, 1320(2), and 1324, Navy Regulations.

On duty independent of a medical officer pharmacist's mates primarily are expected to:

(*a*) Care for the ordinary ailments of the crew of the vessel or station to which they are attached.

(*b*) Administer first-aid to any serious case that may occur.

(*c*) Maintain a sanitary supervision of the vessel or station, and make suitable recommendations to the commanding officer.

(*d*) Maintain a proper amount of medical supplies to meet ordinary conditions.

(*e*) Prepare for forwarding the necessary forms of the Bureau of Medicine and Surgery and keep the required medical records.

(*f*) Investigate the health conditions in ports visited or in adjacent cities and make a report to the commanding officer with such recommendations as may be indicated. Learn and comply with local quarantine regulations.

Whenever contact with medical officers is possible, independent-duty pharmacist's mates should visit them for council and advice. Frequent consultation with the commanding officer is desirable. They should inform him promptly of any suspected contagious or infectious disease that may appear, and when a patient is in need of the services of a doctor. They are expected at all times to be ready to exert themselves to the utmost to assist any person on board in need of assistance by reason of illness or injury, and, so far as may be practicable, to segregate in the sick bay or other designated place any member of the

crew who is on the sick list, and to calmly, quietly, and efficiently aid the commanding officer in the maintenance of the morale of the crew in the presence of disease or injury on board.

Upon reporting for duty independent of a medical officer, pharmacist's mates should, if practicable, communicate immediately with the medical officer having supervision of the medical department of the vessel or station and inform themselves regarding the local organization and the arrangements for obtaining medical assistance when needed. They should accurately check the inventory of medical-department property (if possible with the man being relieved) and report any discrepancies to the commanding officer and medical officer. Do not accomplish a transfer of property unless prepared to assume responsibility for the property reported on the inventory. A pharmacist's mate on independent duty has the same responsibility regarding care of property and submission of reports as a medical officer, and when selected for that duty it is assumed that his training and experience have been such that he can perform such duties and can be trusted with the care of medical-department property without immediate supervision. All health records should be examined and carefully checked for errors and omissions and to see that all members of the crew have been properly immunized against small pox and typhoid fever in accordance with current instructions. Any who have not should be immunized immediately for a single case of small pox or typhoid fever is evidence of gross negligence, particular on the part of the one having custody of the health record at that time. Attempt to locate any missing records and open new ones if necessary.

The space and equipment for use by the representative of the medical department in the care of the sick or injured should be clean and ready for use when the occasion demands.

The question of "how far should I go in treating this case" will present itself time and again to the pharmacist's mate on independent duty. It would be unwise to establish a rule or rules governing this, but it should never be forgotten that the primary duty is to prevent disease, to prevent injuries, and to preserve life and limb of the person afflicted. The capable pharmacist's mate will, considering all things and knowing his own ability, decide what is best for his patient, and the life of the patient often will depend upon this decision.

Section 9.—LABORATORY PROCEDURES AND TECHNIQUE

URINALYSIS AND BLOOD CHEMISTRY

Urinalysis.

Urine is an important and complex excretion formed in the kidneys. It carries in aqueous solution waste products arising from metabolism and products which come directly from substances eaten. The normal constituents of the urine are divided into organic and inorganic groups. The important organic constituents are urea, uric acid, and creatinine; those of the inorganic group are the chlorides, phosphates, sulfates, and ammonia. The normal urine may contain various cellular elements, such as epithelial cells and leucocytes, also a number of crystals which usually form on standing, and are recognized microscopically.

Normal urine as voided is light straw to dark amber in color, acid in reaction, and transparent. Usually the composition of the urine of a given individual, voided in a 24-hour period, does not vary much from day to day; specimens voided at different times in the day may, however, differ markedly.

In qualitative work random specimens may be examined, but a 24-hour specimen is more desirable, and quantitative tests are valueless unless done on the mixed specimen for the 24-hour period. A 24-hour specimen of urine should be collected in a clean container and kept cold, preferably on ice, or protected by a suitable preservative, until examined. Toluene is the best preservative, as it interferes least with the tests which may be performed. One or two cubic centimeters placed in the container to be used for collection of specimen, suffice for this purpose. Thymol also may be used as a urinary preservative. Numerous other preservatives have been used but are less desirable as they may cause false positives or interfere with reactions. The use of preservatives should not be substituted for refrigeration, cleanliness, and care.

ROUTINE EXAMINATION.—Urine for examination should be clear, and may be made so by simple filtration or by filtration after the urine has been mixed and shaken with a small amount of purified talc.

When making a routine urine examination one should:

1. MEASURE THE AMOUNT.—The 24-hour specimen, normally, should be from 1,000 to 1,500 cc. This amount depends upon the balance between the quantity of fluids ingested and the fluids lost by other avenues—perspiration, respiration, fæces (as in diarrhœa), and vomitus.

2. NOTE THE COLOR.—This varies in health and depends upon the concentration. The presence of blood, bile, urobilin, and some drugs will affect the color. A pale urine of high specific gravity suggests the presence of sugar (diabetes).

3. NOTE THE TRANSPARENCY.—Freshly passed urine is usually clear, but upon standing becomes cloudy. Large quantities of amorphous phosphates, amorphous urates, pus, blood, and bacteria produce sediments or cloudy appearances.

4. NOTE THE ODOR.—An *aromatic* odor is due to volatile acids; *ammoniacal* to decomposition; *fruity* to acetone; and *characteristic* odors are produced by certain substances, as asparagus, etc.

5. TEST FOR REACTION.—Acid urine turns blue litmus paper red; alkaline urine turns red litmus paper blue. If the urine is neutral in reaction, no apparent change is produced in the litmus papers. Normally urine is acid in reaction, but soon becomes alkaline upon standing when not refrigerated or preserved.

6. TEST TO DETERMINE SPECIFIC GRAVITY.—Normally this is 1.010 to 1.020. A urinometer is the most convenient means of determining the specific gravity of urine. A special container is filled with urine and a urinometer placed in the container. The urinometer should not touch the sides or bottom of the container and should be read at the bottom of the meniscus. The specific gravity of normal urine varies with the concentration. The sugar content of urine in diabetes causes a high specific gravity.

7. TEST FOR ALBUMIN using the heat and acetic acid test. Fill a clean test tube two-thirds full of clear urine. Filter, if necessary, to clear. Boil the upper portion. Add 3 to 10 drops of 10 per cent acetic acid to acidify and reboil. Compare boiled and unboiled portion and report the degree of turbidity of the coagulated albumin on the basis of 4 plus as a maximum. A turbidity in the boiled portion that clears with the acid is ordinarily due to carbonates or phosphates. Albuminuria is an abnormal condition indicating a leakage of blood-serum albumin into the urinary tract and requires further careful investigation.

8. TEST FOR GLUCOSE (SUGAR) by placing 5 cc of Benedict's qualitative solution in a test tube. Boil. Add 0.5 cc of urine. Boil 2 minutes and let cool. If glucose is present, the blue cupric salt will be reduced to a cuprous salt and the solution will be filled with a green, yellow, or red precipitate. Report on the basis of 4 plus as the maximum red precipitate. Benedict's qualitative solution for urine sugar test is prepared by dissolving 173 Gm. of sodium citrate and

100 Gm. of anhydrous (or 200 Gm. of crystalline) sodium carbonate in 700 cc of hot water and filter. Add slowly, and with constant stirring, 17.3 Gm. of copper sulfate dissolved in about 100 cc water. Cool, and dilute to 1 liter.

Benedict's quantitative solution is used when required to calculate the amount of glucose present. (*See* any standard laboratory textbook for preparation of this solution and procedure).

An occasional trace of sugar in the urine may be an unimportant finding and may occur following general anæsthesia, the administration of certain drugs, in pregnancy, in head injuries, or a meal heavy in carbohydrates. The finding of sugar, however, always warrants carefully repeated examination and, if persistent, carbohydrate tolerance should be tested, the basal metabolic rate ascertained, and the blood sugar content determined in an effort to establish the cause of this abnormal finding.

9. EXAMINE MICROSCOPICALLY.—The uncentrifuged urine may be examined microscopically, especially if allowed to stand and some of the sediment taken up in a pipette, but it is usually preferable to centrifuge the urine and examine the sediment. The casts, pus cells, red blood cells, crystals, and other formed bodies, which may be present in a quantity of urine are, by centrifuging, concentrated and more easily found. The sediment may be examined microscopically either uncovered or covered with a cover glass. In acid urine may be found uric-acid crystals, amorphous-urate deposits, calcium-oxalate crystals, and, rarely, leucin, tyrosin, and cystin crystals, and fat globules; in alkaline urine, amorphous phosphates, calcium-carbonate deposits, and ammonium-urate crystals.

The following organized structures may be found in urinary sediments: Tube casts, epithelial cells, bacteria, red and white blood cells, spermatozoa, and animal parasites. Pus cells and red blood cells, when present, are reported as the number per high-power field in uncentrifuged urine, using a cover glass preparation. As the urine ages the casts and red blood cells decrease in number, also in alkaline urine.

SPECIAL TESTS.—In addition to a routine urinalysis the abnormal constituents named hereafter may be present in the urine and require special tests to determine their presence.

KETONE BODIES.—Acetone and diacetic acid are abnormal acid bodies formed in the acidosis of diabetes, in fevers, and in starvation. The importance of examining urines for ketone bodies, which have been found positive for sugar, should be emphasized. Diabetic patients are frequently first discovered in the coma of diabetic acidosis. This type of acidosis (ketonic) may also be a serious complication in the febrile diseases of childhood.

BILE.—Found in the urine in cases of jaundice.

UROBILIN.—May be found in abnormal amount in conditions in which red blood cells are being destroyed rapidly, in cases of liver insufficiency, or liver infection.

INDICAN.—Caused by the absorption of the products of protein decomposition.

OCCULT BLOOD.—When the presence of blood is suspected but cannot be found by microscopic examination a chemical test may be used.

Blood chemistry.

The blood comes into intimate contact with all the tissues and carries nourishment to and waste materials away from them. It carries those products of the glands of internal secretion which act as chemic excitants, stimulants, or regulators and are known as *hormones*. Insulin from the pancreas, thyroxin from the thyroid, and epinephrine from the adrenals are examples of hormones. The blood carries oxygen to and carbon dioxide away from the

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tissues and is the vehicle through which the *acid-base balance* of the blood is so accurately regulated. The body is continually taking in acid and alkali substances. Much acid is also formed in the body by normal oxidative processes. The sulfur and phosphorus of the proteins are oxidized to sulfuric and phosphoric acids, and the carbon of the carbohydrates forms carbonic acid. The amount of acid formed, neutralized, and excreted in this way in 24 hours equals the acid contained in several hundred cubic centimeters of normal hydrochloric acid. How, then, is the reaction (hydrogen ion concentration or *p*H) of the blood maintained and regulated within the narrow limits necessary? This is accomplished by the so-called *buffer substances* of the body. A buffer in this connection, may be defined as a substance which has the property of stabilizing the reaction of a solution in which it is present; that is, it takes up the acid without appreciable change in its own reaction. When excessive amounts of acid are formed the blood buffers—that is, the *alkali reserve*—of the blood becomes dangerously lowered. Valuable and accurate clinical methods of measuring the alkali reserve and thus determining the degree of acidosis are the measurement of the carbon dioxide combining power of blood plasma and the carbon dioxide content of the alveolar air.

The blood being in such constant and intimate contact with all the organs and tissues, changes in them or alterations of their function are often accurately mirrored by it. Changes in the chemistry of the blood occur as the result of conditions altering formation, utilization, or elimination of substances in the body. Examples of these are changes in the kidneys by which products normally excreted tend to be retained (urea, uric acid, creatinine), or metabolic diseases, such as diabetes, in which the formation of the internal secretion of the pancreas is diminished, and, as a result, the organism loses its power to properly utilize carbohydrates.

Collection of blood.—For analysis blood is collected in the usual manner from a vein in the arm. Chemically clean and dry glassware must be used throughout. It is necessary in chemical work to prevent clotting of the blood. In order that this may be accomplished neutral potassium oxalate in the proportion of 2 milligrams for each cubic centimeter of blood is placed in the flask in which the blood sample is to be collected. For a complete chemical analysis collect about 15 cc. An excess of the oxalate should be avoided, as large amounts may interfere seriously with analysis. A good plan is, where practicable, to obtain the small flasks for collection of the blood specimen directly from the laboratory where sufficient oxalate has already been added to prevent the coagulation of 10–15 cc of blood. Blood for tests is usually drawn before breakfast after an over-night fast.

Certain procedures, such as calcium and phosphorus determinations, agglutination reactions, complement fixation tests, Kahn tests for syphilis, and serum colorimetric determinations require clear, nonhæmolized serum. The blood is therefore taken without the use of the oxalate anticoagulant, allowed to coagulate, and the serum separated.

Special training is required to master the methods used in quantitative analysis of blood and urine. The technique will be found in detail in texts on laboratory procedures.

Normal blood chemical standards per 100 cc are as follows:

Cholesterol	milligrams	140–200
Chlorides (as NaCl in whole blood)	milligrams	450–500
Creatinine	milligrams	1–2
Glucose	milligrams	80–120
Nonprotein Nitrogen	milligrams	25–35

Urea Nitrogen	milligrams	12–18
Uric Acid	milligrams	2–4
Total Protein	grams	6–8.5
Albumin	grams	4.5–5.5
Globulin	grams	1.5–3
Calcium	milligrams	9–11
Phosphorus	milligrams	3–4.5

FUNCTIONAL TESTS

Kidney function.

The ability of the kidney to excrete substances from the blood stream is frequently affected by disease, especially such disease as disturbs the kidney, and is usually diminished after the age of 50 years. Disease of the kidney, however, does not necessarily imply an inability to eliminate substances; that is to say, the functional lesion need not parallel the anatomical. Function, even when serious disease exists, may be normal, especially when the changes are of focal type. Moreover, impairment of renal function does not affect the excretion of different compounds to the same extent. It is well established that functions for chlorides and for urea are independent of each other. In any urine examination, then, one should restrict conclusions regarding impairment of excretory power to the substances under consideration. By combining the findings derived from blood chemistry and other tests of renal function, one is in a position intelligently to adjust the diet, etc., to the excretory powers of the kidney, always bearing in mind, however, that the nutritive need of the body cannot be neglected. Many methods are employed for the determination of kidney function, and their relative values are still debatable. Their multiplicity indicates that no single test is entirely satisfactory, and one should always apply two or more to the case before forming a conclusion. Several kidney-function tests will next be described.

Blood Nitrogen Retention.—Of the nitrogenous constituents in the blood, the kidney excretes creatinine most readily, urea next, and uric acid with the most difficulty. As a consequence, an impairment of function usually results first in the retention of uric acid, then urea, and, finally, creatinine. Owing to the relatively small amount of uric acid and creatinine present, the nonprotein nitrogen, which includes the nitrogen in them as well as in other compounds, is affected very little by alterations in their amounts. The nonprotein nitrogen value is dependent chiefly upon the urea content. This fact is the basis of an intelligent interpretation of the findings. It is said that urea excretion is normal until three-fourths to six-sevenths of the total functional capacity of the kidneys is lost. Nonprotein nitrogen increases only when about 60 per cent has been lost, and retention is rare unless the phthalein excretion is less than 40 per cent for 2 hours. Hence, an increase in urea nitrogen or nonprotein nitrogen means bilaterally impaired function. It has been found that uric acid determination is of much assistance in judging the significance of occasional casts and traces of albumin in the urine, an increase speaking for an organic kidney lesion.

On the usual hospital diet over 20 for urea nitrogen should be considered suggestive of impaired kidney function; over 70 speaks decisively for renal involvement and probable uræmia. Values for creatinine of over 4 do not occur without great impairment of renal function and probability of uræmia.

Dilution Test.—1. Preparation of patient: The day before the test instruct the patient to consume at least 1,000 cc of liquids during the 24 hours and to follow his usual routine in regard to meals. This procedure precludes the test

being performed on an individual whose tissues have been deprived of fluid. 2. Day of test: At 8 a. m. instruct patient to empty his bladder (this urine to be discarded). 3. Patient to drink 1,500 cc of water within 15 minutes. 4. Omit breakfast. 5. Collect specimens of urine in separate containers at 8:30, 9, 9:30, 10, 10:30, 11, 11:30 a. m., and 12 noon. Each specimen should be labeled with exact time of collection.

The patient may receive his usual diet for luncheon and dinner. Test: 1. Measure the quantity of urine obtained in each specimen. 2. Obtain the specific gravity of each specimen. Record as a curve.

NORMAL FINDINGS.—The total quantity voided up to 12 noon should be not less than 1,200 cc nor more than 1,800 cc. The specific gravity of at least one sample should be 1.003 or below.

CLINICAL SIGNIFICANCE.—This test determines the ability of the kidney to dilute urine and excrete water. Deviation from normal indicates impaired renal function.

CONCENTRATION TEST.—Preparation of patient: 1. Instruct patient to take no fluids after the evening meal the day before the test and no fluids at any time during the test and to strictly adhere to the dry diet. 2. At 8 a. m. on the day of the test instruct the patient to empty the bladder and discard urine.

Sample diet for three meals on day of test: At 8 a. m., dry cereal with sugar, syrup, or honey; one egg; toast or bread with butter; no fluid. At 12 noon, roast beef, steak or chops; potatoes (boiled, baked, or riced); bread and butter; jam; no fluid. At 5 p. m., two eggs; bread and butter; jam; no fluid.

COLLECTION OF URINE.—Collect urine in separate containers every three hours until 8 p. m. (11 a. m., 2 p. m., 5 p. m., and 8 p. m.). Samples should be labeled with the hour of collection. Collect night urine at 12 midnight and at 8 a. m. in separate containers.

TEST.—Note the quantity and specific gravity of each sample.

NORMAL FINDINGS.—The specific gravity of one day sample should reach 1.025 or above. The specific gravity of one night specimen should reach 1.030 or above.

CLINICAL SIGNIFICANCE.—The finding of the specific gravity below 1.025 in all day specimens and below 1.030 in all night specimens indicates decreased renal efficiency. These two tests have repeatedly shown impaired kidney function before it could be demonstrated with other kidney function tests. Twenty-four hours should elapse between tests and both tests should be performed before reaching a conclusion as to renal efficiency.

MOSENTHAL TEST.—This test is generally spoken of as the two-hour test. Preparation of patient: 1. To receive the usual diet on the day of the test; also the day before the test. No food or drink is to be taken except at meals. 2. Patient to empty bladder immediately before breakfast (8 a. m.) on day of test (this to be discarded). 3. Collect specimens at 10 a. m., 12 noon, 2 p. m., 4 p. m., 7 p. m., and 10 p. m. Each specimen to be collected in a separate container, properly labeled with the hour of collection. NOTE: The 10 p. m. specimen must not be collected less than 3 hours after the evening meal has begun. 4. Collect all urine from 10 p. m. to 8 a. m. the following morning. This specimen to be in a separate container and labeled "8 a. m. specimen."

TEST.—1. Determine volume and specific gravity of each specimen passed during the day. 2. Measure the night urine (10 p. m. to 8 a. m.) and determine the specific gravity.

SOURCES OF ERROR.—All samples not at the same temperature when specific gravity is taken. Erroneous figures will be obtained unless the samples are at the same temperature when specific gravity is obtained.

NORMAL FINDINGS.—1. Night urine will be less than one-half the quantity of total day urine (usually less than 500 cc). The normal ratio of day to night urine is not disturbed, the normal being 4–1 or 3–1. Night specimen should have a specific gravity of 1.018 or above. 2. One day specimen will usually have a specific gravity of 1.018 or above and 1 day sample will have a specific gravity 8 points lower than the highest specific gravity for the day specimen. Example: Highest specific gravity recorded for any single day sample 1.020; the most dilute will be 1.012 or less in normal findings.

CLINICAL SIGNIFICANCE.—1. Usually the first and most definite evidence of impaired kidney function is indicated by an increase in the night urine, over 500 cc, and the normal ratio of day urine to night urine is disturbed. 2. The highest specific gravity of a day specimen falling below 1.018 is an indication of impairment of renal function. 3. Fixation of specific gravity and an increase in the quantity of urine voided at night (more than 500–700 cc) is definite indication of impaired renal function.

By fixation of specific gravity is meant a variation between extremes of less than 0.008.

Pool all specimens in one container and determine the 24-hour excretion of sodium chloride and nitrogen. Mosenthal states that the results obtained by dividing the urea value obtained by the hypobromite test by 2.14 (the nitrogen factor) is a sufficiently accurate expression of the total nitrogen value for the purposes of the test.

A normal maximal specific gravity indicates that the kidney can concentrate the urine satisfactorily, providing the 24-hour amount of urine is adequate. A high specific gravity with *oliguria* (urine excretion deficiency) occurs only in passive congestion of the kidney, and in acute, subacute, or chronic diffuse nephritis, conditions that also show a markedly diminished sodium chloride excretion, together with considerable albuminuria and œdema. Long life is often possible, providing a low specific gravity is compensated by *polyuria*, (excessive urine secretion) as in diabetes insipidus, chronic nephritis, marked anæmia, during the elimination of œdema, cystitis, pyelitis, polycystic kidney, prostatic hypertrophy, urethral stricture, and paralysis of the bladder, such as occurs in tabes dorsails, tumor of the cord, etc. Such cases may do well as long as there is a compensatory polyuria.

A nocturnal polyuria indicates an overworked kidney and the strain may result in functional damage. Over 500 cc should be considered somewhat suspicious of renal insufficiency. In nephritis it may be improved by curtailing the food intake.

Nycturia (nocturnal urinary incontinence), the result of prostatic or vesical irritation, should not be confused with nocturnal polyuria.

Sodium chloride is being ingested in unnecessary amount if the 24-hour excretion exceeds 5 Gm. A very low excretion, together with œdema, indicates an inadequate elimination, and is then not a criterion of the diet.

If 5 or 6 Gm. of nitrogen are eliminated in the urine every 24 hours, there is sufficient protein in the food to maintain the individual's health and strength, provided the diet contains a considerable amount of starch. Restriction of proteins should be guided by the nature of the disease.

Thus the test supplies information useful in diagnosis, is an early index of renal function, and serves as a guide to diet.

PHENOLSULFONEPHTHALEIN (PHTHALEIN OR RED) TEST.—This was developed by Rowntree and Geraghty, and its simplicity makes it very useful. It estimates only excretory ability at the moment for a foreign substance, is not considered quite as reliable as chemical analysis of the blood, and, of course, does not give

the additional information that the latter supplies; also, in certain cases complete collection of urine sample may be difficult. It is, however, of much value, gives positive results before urea retention appears, has no contraindications, and does compare the kidneys and evaluate each when combined with ureteral catheterization or use of a separator. Diminished excretion of the dye occurs only when about 50 per cent of kidney function is lost. Positive results are of more significance than negative. Values of more than 75 per cent for 2 hours may be accompanied by diuresis, and Frank considers such a finding suggestive of renal disturbance with irritation if there is any corroborative evidence.

The technique comprises administration of the dye, determination of the interval before it appears in the urine, and the amount then excreted during definite periods. The dye is employed in solution, and is conveniently purchased already sterilized in ampules, each containing slightly more than 1 cc of a solution of its monosodium salt of the strength of 6 mg. per cubic centimeter. The patient drinks 200–400 cc of water, and 20 minutes later 6 mg. of the dye is injected intramuscularly into the lumbar muscles or intravenously. The bladder is immediately emptied and the urine discarded. The succeeding portions of urine may be collected by voiding, but it is more accurate to catheterize the bladder or ureters, and catheterization is practically a necessity for determination of the "appearance time."

The "appearance time" is the interval of time elapsing between injection of dye and its appearance in the urine. It is determined by allowing the urine to drip from the catheter into a receiver containing a drop of 10 per cent sodium hydroxide solution. The first traces of the dye will cause a pink color.

The time interval chosen for calculating excretion is then computed from the instant of this appearance. There is considerable diversity in practice as regards this time interval, and it would seem that shorter intervals and quicker results are gaining in preference, as well as being considered equal in value to longer periods.

The percentage excretion of the dye is now measured in each sample of the collected urine. One may employ the simple and inexpensive colorimeter of Dunning, but it is better to prepare a fresh standard, as the colors of such permanent ones tend to fade. It is also preferable to follow the suggestion of Cabot and use standards in test tubes rather than in the ordinary colorimeter, because off colors frequently occur, and a satisfactory match of unknown and standard is then impossible in the latter instrument.

Prepare a 100 per cent standard by diluting 1 cc of the phenolsulfonephthalein solution to 1,000 cc with water. Using test tubes and rack such as those for *p*H determinations, measure into the test tubes portions of this standard, each tube receiving 0.5 cc less than the preceeding one. A series from 6 to 1.5 cc is satisfactory and gives standards representing 60 per cent to 15 per cent with 5 per cent intervals. Add one drop of 10 per cent sodium hydroxide solution to each tube, fill to the 10 cc mark with water, and mix. Dilute the specimen of urine to some convenient volume that will permit a color match in the standard series and estimate its percentage strength, interpolating if necessary. To calculate the per cent of dye excreted in the sample, multiply the determined percentage by the total volume to which it was diluted and divide by 1,000.

After intravenous injection the appearance time is 4–6 minutes normally, and the normal elimination is 35–40 per cent in 15 minutes, 50–65 percent in 30 minutes, and 65–80 per cent for 60 minutes, or for the first 30 minutes it may be stated as about 1 per cent per minute from each kidney.

After intramuscular injection, the normal appearance time is nearer 10 minutes, and the normal elimination is 30–40 per cent in 30 minutes, about 50 per cent (40–60) for 60 minutes, and about 80 per cent (50–85) for 2 hours, or 20–25 per cent during the second hour. If the appearance time is not determined it is customary to allow for it, collecting the first hour's specimen at 70 minutes after injection of dye and the second hour's 60 minutes later.

Impairment of kidney function, of course, increases appearance time and lessens excretion, serious cases not unusually excreting less than 1 per cent during two hours.

When the question of the kidney involved arises, the urine must be taken by ureteral catheterization or by a separator.

Urea Clearance Test.—Preparation of patient: Eats usual breakfast at 8 a. m. without tea or coffee, but water as desired. At 9 a. m. patient voids completely and urine is discarded. Give 100 cc water. At 10 a. m. patient voids *completely.* Save urine and label with time. Give 100 cc water. Take specimen of blood for urea-nitrogen determination. At 11 a. m. patient voids *completely.* Save urine and label with time. If urine specimens are not obtained *exactly* 1 hour apart, the number of minutes must be precisely known by the laboratory. Send all specimens to laboratory. By urea clearance is meant the volume of blood which is entirely cleared of urea by the kidneys in 1 minute.

Sugar Tolerance.—This study of sugar tolerance has clinical value in a variety of conditions. The test is carried out as follows: After an overnight fast, ingest 100 Gm. dextrose dissolved in 300 cc black coffee. Collect blood samples just before feeding and at 45 and 120 minutes after same and determine the blood sugar in each sample. If the blood sugar has not by then returned to normal or about normal one may test further samples taken at hourly intervals. Venous blood, not finger blood which is practically arterial, should be used. The urine may also be collected and tested for sugar.

A normal person should show no glycosuria (excretion of glucose in urine) and his blood sugar will be at its maximum (about 150) within 45 minutes and normal again after 120 minutes. The usual abnormal variation consists in increased height or, especially, prolonged duration of curve before reaching normal, as much as 6 hours being not unusual. The research work reported on the problem of sugar tolerance indicates that it is best to interpret an abnormal curve simply as indicating an impaired sugar tolerance and its degree. High blood sugar and alimentary glycosuria may readily be produced in cases of hyperthyroidism. Hyperglycæmia (excessive glucose in the blood) may occur in nephritis due apparently to raising of the threshold point of the kidney for glucose. Hyperglycæmia and flattened sugar tolerance curves are often found in hypoendocrine (low endocrine secretion) conditions. Low blood sugars (60–90 Mg. per 100 cc) are reported in myxœdema, cretinism, Addison's disease, and pituitary disease.

Gastric analysis.

The stomach mucosa normally secretes 1,000 to 1,500 cc of liquid in each 24 hours. This is called the gastric juice. It mixes with the food so that even if no liquid is swallowed at meal time the stomach contents soon become liquid. The gastric juice contains hydrochloric acid in a concentration of 0.4 to 0.5 per cent, pepsin, rennin, and lipase. These aid in digesting the food. In certain diseases the hydrochloric acid may be increased in amount and in other diseases diminished or absent. Also when the stomach retains the liquid contents too long fermentation takes place and lactic acid develops. Therefore tests are made to determine the amount of liquid present 12 hours after eating, the

percentage of acid, both free and combined, with the food, and the presence of lactic acid. Sometimes easily recognized foods, as prunes, are given the night before and looked for in the residual stomach contents. This fluid is removed by a small rubber duodenal tube passed into the stomach. After the residual stomach contents are removed the tube is left in place while an Ewald test meal is eaten. This test meal consists of 2 pieces of toast (about 35 Gm.) and 400 cc of water. After the test meal small quantities may be removed every 15 minutes until the stomach is empty or the entire stomach contents removed at the end of 1 hour, care being taken to have the patient lie successively on his back, abdomen, right and left sides to facilitate getting all the fluid. The stomach contents thus obtained are examined to determine the quantity of acid, both free and combined, with the food. Also tests are made for pepsin and occult (invisible) blood and a microscopic examination to discover any pus cells, blood cells, yeasts, cancer cells or large fermenting bacteria (Boas-Oppler bacilli).

The acid content is expressed in degrees, indicated °. The number of degrees reported shows the number of cubic centimeters of N/10 alkali needed to neutralize 100 cc of gastric contents.

Duodenal drainage.

A tube is passed into the duodenum and specimens obtained before and after introduction of magnesium sulfate solution. Magnesium sulfate stimulates emptying of the gall bladder into the duodenum. Gall-bladder bile is concentrated and brown in color. The specimens are examined as to amount, color, turbidity, and presence in the sediment of crystals of cholesterin, calcium bilirubin, bile-stained epithelium or leucocytes, and flagellates (Giardia lamblia). If both cholesterin and bilirubin crystals are found in the gall-bladder bile specimen the presence of gall stones is strongly indicated.

Liver function tests.

Icterus Index.—The color of the blood serum is matched against an arbitrary standard of 1–10,000 solution of potassium dichromate in a colorimeter. The normal index is 2–6, latent jaundice 7–15, and clinical jaundice from 16 up. A good test for the degree of jaundice. Harmless pigments such as carotin from foods may color the serum if a fasting blood specimen is not obtained.

Bromsulfalein Dye Test.—The dye is injected intravenously in a dosage of 5 mg. per kilogram of body weight. Samples of blood are withdrawn 5 minutes and 30 minutes after the injection. The blood serum is matched against a standard. Any retention of dye above 50 per cent after 5 minutes, or the presence of any dye after 30 minutes, is indication of hepatic diseases.

Galactose Liver Function Test.—Forty grams of galactose are given on a fasting stomach. The bladder is emptied. Five subsequent hourly specimens of urine are collected and Benedict's quantitative test for sugar is performed on each. Excretion of over 3 grams of sugar is assumed to indicate hepatic functional impairment.

Van Den Bergh Test.—Ehrlich's diazo reagent is added to blood serum and the time of appearance of the maximum color is noted. If a reddish violet color appears within 30 seconds the reaction is *immediate direct* and indicates obstructive jaundice. If the color appears after 30 seconds the reaction is *delayed direct* and indicates hæmolytic jaundice. An indirect reaction is a quantitative test for bilirubin in the serum by adding diazo reagent followed by alcohol and ammonium sulfate. Normal serum contains from 1–3 mg. of bilirubin per liter. Any amount above this is abnormal.

UROBILINOGEN TEST.—Ehrlich's reagent is added to urine. A pinkish color appears in the presence of urobilin. A positive test in a dilution up to 1–10 is normal. Diffuse liver damage is indicated by positive tests in higher dilutions of the urine. A negative test in undiluted urine is found in complete obstruction of the common bile duct. Urobilin is formed in the intestine by the action of bacteria on bilirubin. It is reabsorbed and reconverted into bilirubin by the liver and reexcreted in the bile, except for a small amount which is normally passed in the urine. If the liver is damaged it is unable to convert the urobilin to bilirubin and it passes out in the urine. If the common bile duct is completely obstructed no bile enters the intestine and no urobilin is formed.

BACTERIOLOGY

This discussion of bacteriology and hæmatology is not intended to serve as a working manual for laboratory use, but rather to outline the principles involved, the general methods, and something of the application of the more common procedures. Details of technique that are absolutely essential for the proper performance of any test are available in the manuals of laboratory work that are supplied to the medical department of all ships and stations.

The microscope.

The most important single piece of apparatus in a laboratory is the microscope, and it must be used and cared for accordingly. It is used to magnify and so make visible to the eye very small bodies, such as bacteria, the eggs of intestinal parasites, and the material found in urine sediments. A simple microscope is nothing more than a single magnifying lens. A compound microscope, which is the type used in medical laboratories, consists of a number of such lenses arranged in line so as to give a very great magnification, even up to 1,000 times the actual size. Complete and detailed descriptions of microscopes are to be found in all books on laboratory work.

Before attempting to use a microscope for the first time one should read over a description of its parts and their functions so that it will be possible to adjust the light and the lenses properly. There are a few important things to keep in mind regarding its use, and they are: Never leave the microscope exposed to direct sunlight, excessive heat, or splashing water; never use ether, alcohol, or xylol to clean it, as they all destroy the finish; never pick it up by any of the movable parts; never leave immersion oil on the lens or objective, as it is called, but wipe it off immediately after use with a fine, soft cloth or with special lens paper; when not in use see that it is well covered to protect it from dust.

MICROMETRY is the measurement of microscopic bodies. The unit is called the micron and is one one-thousandth part of a millimeter, or one twenty-five thousandth of an inch. A glass disk, with a scale etched on it, is inserted in the eyepiece of the microscope and there it is at the level at which the image of the object on the stage is brought to a focus. The lines of the scale seem to cut the object and the number of divisions of the scale covered by the object is noted. The scale must be standardized for each objective of each microscope it is used with. Since the value in microns of one division is thus known and, knowing how many divisions are covered by the object, its size is determined by multiplying these values.

Culture media are the materials used for the growth of bacteria in the laboratory. Simple media are so made that they simulate to a greater or lesser degree the conditions present in the human body, where the bacteria have been grow-

ing. The basis of most media is bouillon or broth which is a solution of meat juice, salt, and peptone in water and having a definite degree of acidity. The acidity may be determined by titration. The more modern and satisfactory method is to determine the hydrogen ion concentration or its pH value. The usual pH value is about 7.5, approximating that of blood. A few bacteria require media of other values for their cultivation. Simple *nutrient broth* may be modified by the addition of agar, making it solid, and is then known as *nutrient agar.* To the latter blood may be added, producing *blood agar.* In the same way other body fluids, such as hydrocele fluid, may be added, making the enriched media required by some of the more delicate organisms.

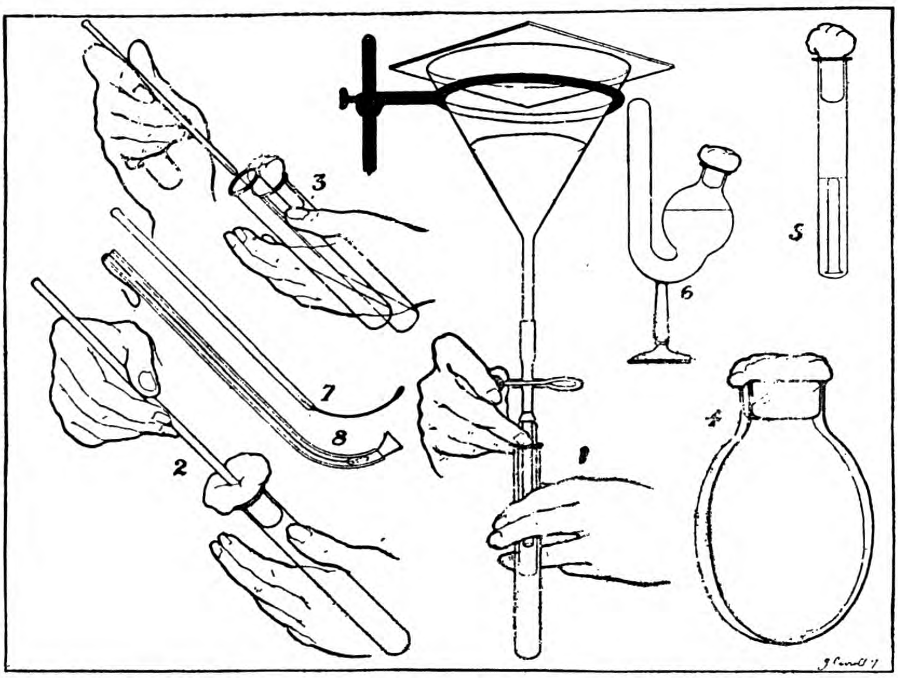

FIGURE 167.—1, Filling tubes; 2, plugging tubes; 3, inoculating tubes; 4, culture flask plate; 5, Durham fermentation tube; 6, Smith fermentation tube; 7, pharyngeal loop for meningococcus pharynx cultures; 8, West tube for same. (Stitt.)

Other substances are used as media, such as milk, broth with sugars added, coagulated blood serum (Löfflers, particularly useful for Corynebacterium diphtheriæ), and many others used for special purposes. Milk is used to determine whether the organism produces acid by fermenting the lactose of the milk (shown by a change in the litmus indicator) and whether it produces enzymes that will coagulate the milk. Sugar broth is used in fermentation tubes and always contains an indicator such as litmus. If an organism produces acid, the indicator changes color. If it produces gas as well, some of the gas is collected in the closed branch of the tube. The various activities of organisms on culture media, such as the appearance of the colony, production of acid and gas in one sugar and not in another, have been classified and serve to identify the specific organism. Media, after preparation, are put up in tubes—fermentation tubes, flat glass dishes with covers known as Petri dishes, or in flasks, and are then sterilized.

STERILIZATION of culture media is accomplished by means of heat, either from streaming steam in an Arnold sterilizer or by steam under pressure in

an autoclave. Glassware often is sterilized by dry heat. Fractional sterilization is repeated sterilization at 1 to 24 hour intervals and is employed to kill bacteria developing from spores. As the dust of the air is loaded with bacteria all media must be kept covered or, if in tubes, plugged with cotton from the time first made.

Bacteria are very small single-celled bodies, visible only through a microscope. They are distributed almost universally in soil, air, water, and in the human body. The mouth and throat contain enormous numbers; milk and butter contain millions. The large intestine contains countless numbers, and a large part of the solid matter of the fæces is made up of bacteria. It is evident, therefore, that not all of these bacteria produce disease, and some of them are harmless or even distinctly beneficial to the body and are called *nonpathogenic*. Many bacteria are known to produce disease, and these are called *pathogenic*. In order to study bacteria they are grown on culture media, the different organisms separated out and then grown in pure culture for identification. As the majority of bacteria of medical interest grow in the human body the media employed for laboratory growth must be kept at body temperature; hence cultures are kept at a constant temperature of 37.5° C. This is known as incubation and usually is continued for 24-hour periods.

Bacteria are classified according to the appearance of colonies, the shape and arrangement of the individual cells, their color when stained by appropriate methods, whether or not they are motile (have the ability to move from place to place in fluid), by their action on milk and sugar bouillon and by their action on experimental animals. The three usual types are the round organisms, or *cocci*, rod shaped, or *bacilli*, and spiral forms, or *spirillæ*. All of them are killed by boiling, many of them by a lower temperature if prolonged sufficiently. Some grow only in the presence of oxygen and are called *aërobes*, while others require an atmosphere free of oxygen and are called *anaërobes*. They reproduce by *fission* or simple splitting into parts. Some of them produce bodies called spores that are much more resistant to high temperatures, drying, and cold than the bacteria and serve to produce new organisms when material containing them again is placed in surroundings favorable to bacterial growths.

Filtrable viruses are organisms so minute that they will pass through the pores of a porcelain filter. They cause the following diseases: Small pox, varicella, lymphogranuloma inguinale, foot and mouth disease, herpes febrilis, epidemic encephalitis, poliomyelitis, rabies, benign lymphocytic chorio-meningitis, influenza, common cold, measles, mumps, dengue, yellow fever, and sandfly fever.

Smears are thin spreads of pus, blood, bacteria, or similar material on a glass slide. They may be made from material from the throat, from sputum, from an abscess, or of blood. The first essential for a proper bacteriological examination is a good smear, and the chief difficulty is to get it thin enough. If a culture is to be examined, place a loopful and a drop of distilled water on a perfectly clean glass slide and with a sterile platinum wire rub up some of the bacteria in the water, spreading it over as large an area as possible. If the bacteria are in fluid media, the water is not needed. For examination of pus use a cotton swab or a loop and spread out just enough of the material to make a visible film on the slide. Smears of sputum should be made from fresh material—that is, material recently coughed up from the lungs and as free of mouth secretions or saliva as possible and collected in a clean container. For the smear select a thick lump of mucus and avoid the frothy, watery saliva. Smears are allowed to dry in the air and then are fixed to the slide by passing through a flame two or three times. Blood smears should not be fixed by such

heating. The smear then is ready for staining with whatever dye is indicated, Gram's method being the best routine process for most bacteria, except the tubercle bacillus which requires the acid fast staining method.

STAINS are substances used to color bacteria and tissue cells so that their morphology may be studied microscopically. They are usually solutions of anilin dyes in water or alcohol, but a few are derived from vegetable substances. The more common stains are hæmatoxylin and eosin, used for tissue staining, and methylene blue, carbol fuchsin, gentian violet, and safranin for bacteria. Each of these is made up for use in definite strength, alone or in combination with another dye. For some purposes several stains are applied successively, as part of the material will take up and retain one stain while other parts will react with another dye. This is the principle of Gram's method and of acid-fast staining for tubercle bacilli.

Gram's stain.—1. Stirling's gentian violet solution: Five grams of gentian violet are ground in a mortar with 10 cc of 95 per cent alcohol. After practical solution, 2 cc of anilin oil are added and then 88 cc of distilled water. The grinding is continued a short time and then the mixture is let stand a day or two when it is filtered through paper. It has the merit of staining quickly and intensely and of keeping many months.

2. Gram's iodine solution: The formula for this solution is:

Iodine	1 gram.
Potassium iodide	2 grams.
Distilled water	300 cc.

3. Decolorizing agents: Alcohol and acetone, equal parts; or alcohol, 95 per cent.

4. Counterstains: (*a*) Dilute carbol fuchsin: One part carbol fuchsin in 10 parts water; (*b*) Safranin: 10 cc of saturated alcoholic solution of water soluble safranin with 90 cc of distilled water.

5. Technique: The film should be thin, dried in the air, and fixed by passing through the flame or with methyl alcohol. The gentian violet is applied for one-half minute and washed off. The Gram's iodine solution is applied for one minute or longer and washed off. Alcohol 95 per cent or alcohol and acetone equal parts are now dropped on the film until no more violet color streams out.

Wash with water and apply one of the counter stains for 1 or 2 minutes.

Gram-positive bacteria are stained a deep violet, whereas the Gram-negative organisms take the color of the counter stain.

Method of staining acid-fast bacilli.—Carbol fuchsin (Ziehl-Neelsen), saturated alcoholic solution of basic fuchsin, 10 cc, and 5 per cent aqueous solution of phenol, 100 cc.

(*a*) Dry smear in air and fix by passing through flame or with methyl alcohol.

(*b*) Flood smear with stain and gently steam for 3 to 5 minutes. Wash in water. Decolorize with 95 per cent alcohol containing 3 per cent hydrochloric acid, until only a suggestion of pink color remains.

(*c*) Wash in water.

(*d*) Counterstain with saturated aqueous solution of methylene blue.

(*e*) Wash, dry, and mount.

(*f*) Acid-fast organisms are stained red, other organisms and cells blue. Important acid-fast organisms are the tubercle and leprosy bacilli.

BLOOD CULTURES are made to determine whether bacteria are present in the blood stream, thus serving as an index of the nature of the disease in some

cases. Ordinarily about 10 to 20 cc of blood are required. It is taken from a vein by means of a needle and syringe or a needle connected by sterile tubing with a flask, observing strict asepsis throughout. The skin over the vein is sterilized with Tr. iodine and alcohol prior to the taking of the blood. The blood is received in sterile containers and transferred to appropriate media. Usually it is added to bouillon and in varying proportions to melted agar that has been cooled below 45° C. and then is poured into Petri dishes and incubated.

Blood for the Wassermann reaction and Kahn test are taken in the same manner, preparing the patient's arm, constricting above with a tourniquet, and puncturing a vein with a needle. Here, as absolute asepsis of the blood is not required, the blood may be permitted to run from the end of the needle into a tube, but it is better to collect it in a closed system of apparatus.

DARK-FIELD EXAMINATIONS usually are made on serum from sores on the genitalia to detect the *Treponema pallidum*, the organism causing syphilis. For this purpose a special substage condenser replaces the ordinary Abbe condenser of the microscope. It is so constructed that light rays are prevented from passing directly from the mirror to the objective by a light-proof black surface. Light is reflected by means of mirrors around the sides of this dark field and so illuminates the organisms or cells that may be present in the fluid on the slide. Ordinary daylight is not sufficient, and special lamps are required.

To make the preparation the suspected sore is cleaned of all accumulated secretions with sterile gauze and physiological salt solution. Then it is rubbed sufficiently to promote a flow of serum but not to draw blood. A drop of this material is placed on a slide and immediately covered by a water glass and examined while still moist. The *Treponema pallidum* is examined in a dark-field preparation because it does not take the ordinary dyes, and when stained by one of the more complicated methods loses many of its characteristics. Other organisms may be seen in the dark-field preparation, but as they are stained easily, this method is not employed. There are a number of spiral-shaped organisms that occur in ulcerative lesions, so great care must be exercised in making a positive report of *Treponema pallidum.*

BACTERIOPHAGE is a filtrable, particulate substance which causes lysis or dissolution of susceptible bacteria. It can be obtained from fæces or sewage and can be transmitted indefinitely from one culture to another with increase in quantity.

AGGLUTINATION TESTS.—If the serum of a typhoid fever patient is added to a culture of typhoid bacilli clumping or agglutination of the bacteria takes place. This is called the *Widal reaction.* Several other diseases can be diagnosed by agglutination tests, among them meningitis, tularæmia, undulant fever, cholera, paratyphoid fever, using the patient's serum and the causative organism.

PNEUMOCOCCUS TYPING.—Thirty-two strains of pneumococci have been identified. If rabbits are injected with these strains 32 specific serums can be obtained which when added to pneumococci in pneumonia sputum cause swelling of the capsule of the organism enabling the specific strain to be identified. This is the *Neufeld reaction.*

SENSITIZATION TESTS.—Many people are hypersensitive (allergic) to certain proteins (foods, epidermals, pollens) and suffer from asthma, hay fever, urticaria, etc. Extracts of the proteins when applied as a scratch test or intradermally produce a local urticarial wheal in a person sensitive to the particular substance. (*See* section on Allergy.)

Friedman test for pregnancy.—If the urine of a pregnant woman is injected intravenously into a virgin female rabbit, hæmorrhagic follicles can be seen in the ovaries of the rabbit within 24 hours. This test is of great value in the early diagnosis of human pregnancy.

Schick test.—Inject intradermally 0.1 cc of diphtheria toxin. If a reddened area appears within 24 hours and reaches a maximum after 2–3 days the test is positive and indicates that the individual is lacking in antitoxin and is susceptible to diphtheria.

Dick test.—Scarlet-fever toxin is injected intradermally. If the person is susceptible to scarlet fever a red infiltrated area appears within 24 hours.

Mantoux test.—Tuberculin is injected intradermally. A local reaction indicates past or present tuberculous infection. If a scratch test is used it is called a **Von Pirquet test.**

Frei test.—An antigen made from an emulsion of a mouse's brain infected with the virus of lymphogranuloma inguinale is injected intracutaneously. A local reaction which persists for 3 days or longer is diagnostic of lymphogranuloma inguinale.

Paul and Bunnel test.—When the human serum is added to sheep corpuscles agglutination occurs at dilutions of 1 to 8, or 1 to 16. Serum from patients with infectious mononucleosis agglutinates sheep cells in high dilutions. Serum from leucæmic patients agglutinates in dilutions of 1 to 4 or less.

Following is a list of important pathogenic bacteria and the diseases in which they are the primary causative agent:

Organism	Disease
Gram Positive	
Bacillus anthracis	Anthrax.
Clostridium tetani (*B. tetani*)	Tetanus (lockjaw).
Corynebacterium diphtheriæ (*B. diphtheriæ*)	Diphtheria.
Diplococcus pneumoniæ (*Pneumonoccus*)	Pneumonia.
Mycobacterium lepræ (*B. lepræ*)	Leprosy.
Mycobacterium tuberculosis (hominis) (*B. tuberculosis*).	Tuberculosis.
Staphylococcus	Boils, abscesses.
Streptococcus	Cellulitis, scarlet fever.
Gram Negative	
Eberthella typhosa (*B. typhosus*)	Typhoid fever.
Hæmophilus ducreyii (*B. of chancroid*)	Chancroid.
Hæmophilus influenzæ (*B. influenzæ*)	Bronchopneumonia.
Klebsiella pneumoniæ (*B. pneumoniæ*) (Friedlander).	Pneumonia.
Neisseria gonorrhœæ (*Gonococcus*)	Gonorrhœa.
Neisseria intracellularis (*Meningococcus*)	Epidemic meningitis.
Pasteurella pestis (*B. pestis*)	Plague.
Pasteurella tularensis (*Bacterium tularense*)	Tularæmia.
Salmonella enteritidis (*B. enteritidis*)	Food poisoning.
Salmonella paratyphi (*B. paratyphosus (A)*)	Paratyphoid fever A.
Salmonella schotmülleri (*B. paratyphosus (B)*)	Paratyphoid fever B.
Shigella dysenteriæ (*B. dysenteriæ*)	Dysentery.
Vibrio comma (*Spirillum choleræ*)	Cholera.

HÆMATOLOGY

Counting blood cells.

COMPLETE BLOOD COUNT.—This includes the determination of the number of red and white cells in 1 cubic millimeter of blood, the percentage of hæmoglobin, and a differential count which determines the percentage of each type of white cells present. Cells are so numerous in the blood that it must be diluted to separate them and permit the counting of individual cells. The dilution is accomplished in special pipettes (marked 101 for red count and 11 for white count), first taking up blood and then the proper diluting fluid. The pipettes are so graduated that known dilutions may be made. One part of blood to 200 parts of fluid gives a dilution of 1–200 for the red pipette and 1–20 for the white. The pipettes must be clean and dry before use, and this is accomplished by washing out with water, sucking alcohol through to wash out the water, then ether to take out alcohol, and then air to evaporate the ether. The bulb of the pipette or mixing chamber contains a glass bead to aid in thoroughly mixing the diluted blood; and if cleaned properly, the bead will not stick to the sides of the bulb.

RED BLOOD COUNT.—Cleanse finger tip with alcohol, let dry. Puncture with sterile needle. Draw blood to exactly 0.5 mark, wipe off tip. See that the blood column reaches from the tip to mark. Draw up diluting fluid (Hayem's) to 101 mark. Cover ends of pipette with thumb and finger and shake vigorously to thoroughly mix. Blow out 2 or 3 drops and discard, then apply a drop to the top of the ruled platform of the counting chamber of the hæmacytometer at the edge of the cover slip and allow enough of the diluted blood to run in by capillary attraction to fill the space beneath the cover. This space is 0.1 mm. deep. Allow erythrocytes to settle and using the high dry objective find the large center square which is divided into 400 small squares. Count the number of red cells in 80 of these squares and add four ciphers for the correct red blood count. A normal red blood count is 4.5 to 5 million per cubic millimeter. Hayem's solution consists of bichloride of mercury 0.5, sodium sulfate 5, sodium chloride 1, distilled water 200.

WHITE BLOOD COUNT.—Draw blood to 0.5 mark and diluting fluid (3 per cent acetic acid, or tenth normal hydrochloric acid to the 11 mark. Mix and blow out two drops. Fill the counting chamber. Allow to settle and count the leucocytes under low power in those square millimeters at each of the 4 corners of the Neubauer ruled areas and multiply the total by 50. A normal white blood count is 5 to 10 thousand per c. mm. of blood. A count below 5,000 is called a *leucopœnia* and above 10,000 a *leucocytosis*.

DIFFERENTIAL COUNT.—This is made on a stained smear of undiluted blood. Smears are made on slides or cover slips that are clean and free of all grease. Smears on slides are made by drawing out a drop of blood on one slide by means of the end of another slide. With cover slips, a drop of blood is taken up on the center of one and a second dropped on it. The blood spreads out rapidly in a thin film and then the slips are separated by a sliding motion. Both methods are illustrated. The smears are dried in the air and then stained with Wright's stain. This stain is made by adding 0.3 Gm. of the dye to 100 cc of pure methyl alcohol and put aside for a few days to ripen. To stain cover blood smear with the stain for one minute then dilute with equal amount of freshly distilled water and allow to stain for 3 to 6 minutes. Wash off, let dry and examine with the oil immersion objective, counting 100 cells. The number of each type of white cells then gives the percentage of each. The identification of the various types of leucocytes is best learned by examining many slides with the aid of an experienced technician.

The SCHILLING CLASSIFICATION of leucocytes for differential count and their normal percentage follows: Basophiles 0–1, eosinophiles 2–4, myelocytes 0, juveniles 0–1, band forms 3–5, segmented neutrophiles 51–67, lymphocytes 21–35, monocytes 4–8. In severe infectious diseases the number of band and juvenile forms increases at the expense of the segmented neutrophiles and is known as the "shift to the left." In certain diseases abnormal or pathological cells appear. Among the latter are the myeloblasts and myelocytes of myelogenous leucæmia and the lymphoblasts of lymphatic leucæmia.

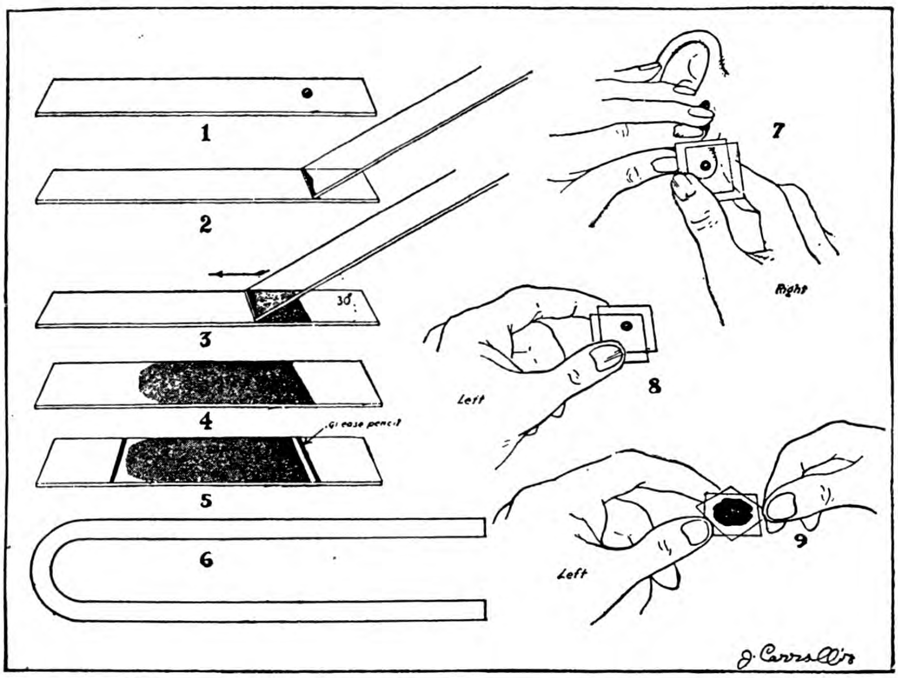

FIGURE 168.—1, 2, 3, 4, Making blood smears on slide; 5, smear ready for staining—grease marks prevent Wright's stain from running over slide; 6, U-shaped glass tubing to hold title in staining; 7, right hand holding two cover glasses—one cover glass is being touched to drop of blood from ear; 8, cover glasses transferred to left hand in preparing to place one cover glass on another and spread film; 9, separating cover glasses by sliding one from the other. (Stitt.)

The stained smear also is used to demonstrate the presence of malarial parasites, the staining qualities of the red cells, and their shape, size, and whether or not any of them show nuclei.

HÆMOGLOBIN is the coloring matter of the erythrocytes and is estimated by adding tenth normal hydrochloric acid to blood (which converts hæmoglobin to hæmatin) and comparing the color with the color scales of a Sahli or Haden-Hausser hæmoglobinometer. It is reported either in per cent of normal or as grams per 100 cc of blood.

COAGULATION TIME of the blood is determined by filling a piece of capillary glass tubing with blood. At half minute intervals break off a portion. When coagulation has taken place a wormlike coagulum can be pulled out. Normal coagulation time is 3 to 6 minutes. A long coagulation time is seen in hæmophilia and some jaundiced patients.

SEDIMENTATION TEST.—Five cc of blood are placed in a Cutler graduated tube containing 0.5 cc of 3 per cent sodium citrate solution to prevent clotting.

As the blood settles a reading is made every 5 minutes for 1 hour and recorded on a graph. The normal sedimentation index for men is 2–8 mm. It is slightly higher for women. Sedimentation increases with increasing destructive processes of disease, hence is a good prognostic indicator.

ANIMAL PARASITOLOGY

General considerations.

While there are many lower forms of animal life that are parasitic for man, only the most common ones will be considered in this section. Before discussing the systematic relationships, structure, and life history of these parasites, there are certain terms employed in animal parasitology which it is necessary to understand. Among these are:

1. *Hosts.*—The animal in which a parasite undergoes its sexual life is called the definitive or final host, that in which it passes its nonsexual or larval existence the intermediate host. For example: Man is the intermediate host of the malarial parasite, the mosquito the definitive host.
2. *True parasitism.*—By this is understood the condition where the parasite does harm to the host, deriving all the benefit of the association. A good example of this is the hookworm infecting man.
3. *Mutualism.*—In such an association there is mutual benefit to each party of the association. An instance of this would be the oyster crab found inside the oyster shell.
4. *Commensalism.*—Where there is benefit to the parasites but no injury to the host. An example of this would be the *Endamœba coli* in the intestine of man.
5. *Ectoparasites.*—Those living upon the body of the host. Example: Infestation with lice.
6. *Endoparasites.*—Those living within the body of the host. Example: Infection with hookworms.
7. *Male* parasites are designated by the sign of Mars (♂); the *female* by the sign of Venus (♀).
8. The *name* of a parasite consists of its generic and specific names. The first or the generic name always commences with a capital. Example: *Cimex lectularius*, the name of the bedbug.

Classification.

Practically all animal parasites of man belong to the following zoological phyla, or branches: 1. Protozoa (one-celled animals); 2. Vermes (lower worms); and 3. Arthropoda (mites, ticks, and insects).

PROTOZOA are one-celled animals and are made up of protoplasm, which is divided into cytoplasm and a nucleus. There are four groups of protozoa as follows: 1. Sarcodina; 2. Flagellata; 3. Infusoria; and 4. Sporozoa. (Fig. 169.)

SARCODINA.—This class of protozoa moves and secures food by throwing out protoplasmic projections called pseudopodia, or false feet. *Endamœba histolytica*, one of the parasitic intestinal amœba of man, is the important member of this class. It exists in two stages, motile and encysted. Man acts as the definitive host. An intermediate host is not required. It is transmitted by cysts in food or water. Flies may act as carriers. It causes the disease known as amœbic dysentery. Diagnosis is made by finding the motile or encysted amœba in the stools.

FLAGELLATA.—This class sometimes is called the Mastigophora and includes those protozoa that move and obtain food by means of whiplike appendages, or flagella. *Trypanosoma gambiense* is an important member of this group. This

parasite is fish-shaped, has two nuclei and a long flagellum. It lives in the blood and tissues of man. For its development two hosts are required: A fly (*Glossina palpalis*), the definitive host, and man, the intermediate host. It is transmitted by the fly biting man. It causes the disease known as trypanosomiasis, or sleeping sickness, a disease found chiefly in Africa. Diagnosis is made by finding the trypanosome in the blood or tissues of man. Intestinal flagellates such as Trichomonas, Chilomastix, and Giardia, are frequently found in an examination of the stools. Trichomonas vaginalis is an important flagellate often found in vaginal discharges.

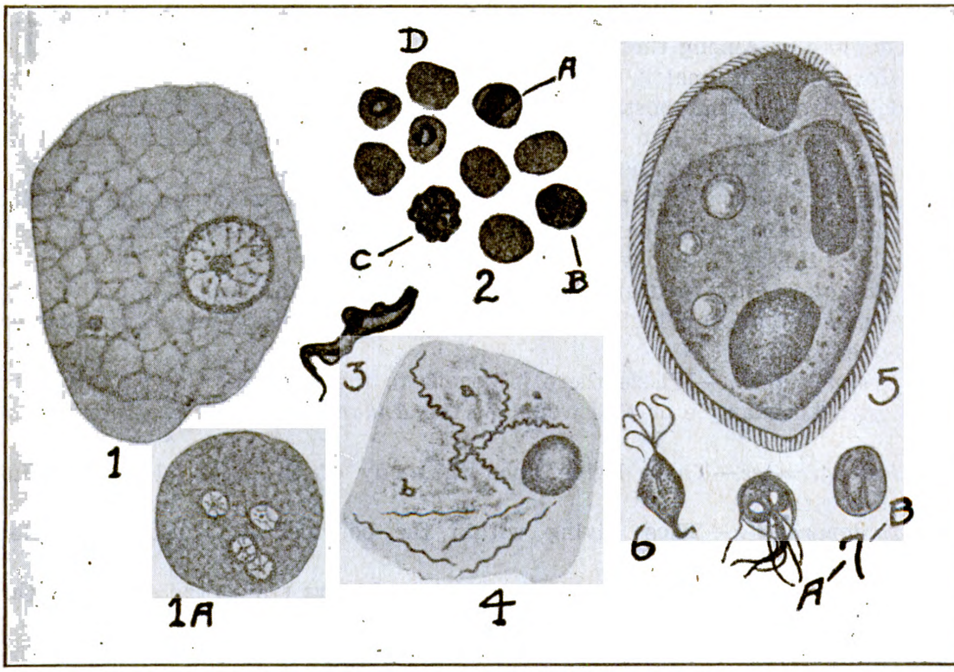

FIGURE 169.—Parasitic protozoa of man: 1, adult *Endamoeba histolytica;* 1a, encylsted *E. histolytica;* 2, *Plasmodium malariae,* A, B, C, D, various stages; 3, *Trypanosoma gambiense;* 4, a, *Treponema pallidum;* b, *Borrelia refringens;* 5, *Ballantidium coli;* 6, *Trichomonas hominis;* 7, a, adult *Giardia lamblia;* b, encysted *G. lamblia.* (Stitt.)

INFUSORIA.—This group frequently is called the Ciliata on account of the fine, hairlike fringe or cilia that surrounds them. These cilia aid in movement and securing food. *Balantidium coli,* a rather large intestinal protozoan, is the only member of this group of importance to man. It is transmitted similarly to *Endamœba,* and causes dysentery. Diagnosis is made by finding the parasite in the stool.

SPOROZOA.—The protozoa have neither cilia, flagella, nor other organs for movement. They live parasitically in the tissue cells of the host, and reproduce by forming spores. The ones that live in the red blood cells, *Hæmosporidia,* are of the most interest medically because they include the parasites that cause malaria. There are three types of malarial parasites of man: 1. *Plasmodium malariæ,* the cause of quartan malaria; 2. *Plasmodium vivax,* the cause of benign tertian malaria; and 3. *Plasmodium falciparum,* the cause of malignant tertian (æstivo-autumnal) malaria. These parasites require two hosts for their development, the definitive host, a mosquito (Anopheles), and man, the intermediate host. The development in the mosquito requires 10 to 21 days;

thus, an anopheles mosquito biting a man suffering from malaria cannot infect another man until after this time has elapsed.

In the body of a mosquito which has been infected by biting a person having some form of malaria the malarial parasite develops for from 10 to 21 days and then appears in the salivary glands of the mosquito in the form known as *sporozoites* and is ready for transmission to another host. By the bite of the infected mosquito the sporozoites are introduced into the blood stream of the new host where they enter the red-blood cells and are known as *trophozoites.* In the red cells the trophozoites rapidly mature, the benign tertian type in 48 hours, the quartan in 72 hours, and the malignant tertian in about 48 hours, and when full-grown they are termed *schizonts.* The nucleus of a schizont divides into minute particles which scatter through the cytoplasm of the parasite, later to become the nuclei of new parasites, and the cytoplasm splits into segments which each contain a nuclear particle and are called *merozoites.* The red cell then ruptures and the merozoites are released into the plasma whence they seek and enter fresh red cells where the cycle is repeated. Reproduction of the parasites continues for about 2 weeks (the *incubation* period) at the end of which time a sufficient number have been produced to cause the symptoms characteristic of malaria, the chill followed by fever. The chill in malaria is coincident with the rupturing of the red cells and is attributed to the sudden liberation into the blood of toxic substances, possibly excretory material of the parasites, from the disintegrated red cells.

Diagnosis is made by examining a blood smear for the presence of these parasites.

VERMES are divided into two classes, the *platyhelminthes,* or flat worms, and the *nemathelminthes,* or round worms.

PLATYHELMINTHES.—Of these parasites, known only as the flat worms, there are two classes: 1. The trematodes or flukes; and 2. The cestodes or tapeworms.

Trematodes or *flukes* are generally leaflike in shape and vary considerably in size. Characteristic of them is the possession of suckers, by which they hold on to the skin or alimentary tract of their host. They develop from eggs, and the larval stage usually is passed in a snail. Some flukes require, in addition to the snail, a second intermediate host, usually a fish. Man, the definitive host, contracts the parasites by eating insufficiently cooked fish or by bathing in or drinking infected water. The flukes of importance to man are: 1. *Fasciolopsis buski,* which parasite lives in the intentine, the diagnosis being made by finding the fluke or its eggs in the stools; 2. *Clonorchis sinensis,* an important liver fluke, the eggs of which likewise are found in the stools; 3. *Paragonimus ringeri,* the fluke that lives in the lungs, the diagnosis being made by finding eggs in the fresh sputum; and 4. *Schistosomes,* which are the blood flukes, of which there are three kinds, *Schistosoma hæmatobium, S. japonicum,* and *S. mansoni.* Unlike the other flukes, the blood flukes are not hermaphroditic, but have separate sex. Diagnosis is made by finding the eggs in the fæces or, in the case of *S. hæmatobium,* in both urine and fæces.

Cestodes or *tapeworms.*—These consist of a head and a series of segments. The head, which is a little larger than a pinhead, is provided with suckers or hooks, or sometimes both, to enable them to hold on to the intestine. The segments may number several hundred or more. Some tapeworms attain the length of 25 or 30 feet. In treating cases of tapeworm infection, it is important that the head be expelled, otherwise, in about two months, a full-grown worm again will develop. Among the important tapeworms of man are: Tænia saginata, Tænia solium, Hymenolepis nana, and Diphyllobothrium latum. 1. *Tænia saginata* is the common and widely distributed beef tape-

worm. Its head has four large suckers but no hooklets and it often is called the unarmed tapeworm. The segments have a uterus showing 15 to 30 branches. The genital pores are lateral and alternate. Several hundred segments may be present, and the worm varies from 10 to 25 feet in length. Man is the definitive host and cattle the intermediate host, infection being brought about by eating insufficiently cooked beef. 2. *Tænia solium* is the so-called pork tapeworm and is not as common as the beef tapeworm. Its head shows, in addition to suckers, a rostellum crowned by hooklets, for this reason often being called the armed tapeworm. The segments have a uterus showing only 5 to 10 branches. Man is the definitive host and the hog the intermediate

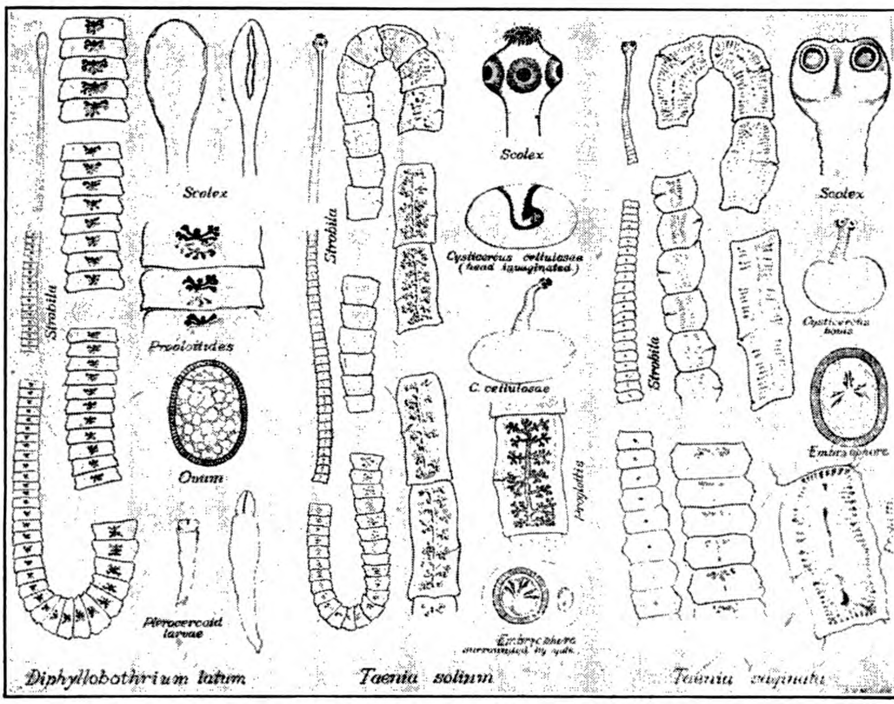

FIGURE 170.—Adult and larval stages of cestoda of man. (Stitt.)

host. Infection is contracted by eating insufficiently cooked pork. 3. *Hymenolepis nana* is one of the most common tapeworms and is called the dwarf tapeworm on account of its small size, it being only a quarter to a half inch in length. Its head has four suckers and a rostellum with a single row of hooklets encircling it. There are about 150 to 200 segments. The genital pores are lateral and all are on the same side. Man acts as both the definitive and intermediate host. As many as 1,000 worms may be present at one time. Infection is caused by swallowing the eggs. 4. *Diphyllobothrium latum*, the broad Russian tapeworm, has an olive-shaped head, with two slitlike suckers, broad segments with a rosette-shaped uterus, and may reach more than 30 feet in length. Segments sometimes number 3,000 or more. Man, the definitive host, contracts the infection by eating insufficiently cooked fish. Two intermediate hosts are recognized—first a cyclops (a minute, one-eyed shellfish) and second a fish. The eggs are operculated (have a lid) and the worms do not have the hooklets characteristic of the other tapeworms previously discussed.

The diagnosis of these worms is made by finding their segments or their eggs in the stools. (Fig. 170).

NEMATHELMINTHES.—These worms are known as roundworms on account of being tubular or filiform in shape. They are not segmented and are covered by a cuticle or skin, which is frequently ringed. An alimentary canal is usually present and complete. The sexes as a rule are separate. The male usually can be recognized by its smaller size, its curved posterior end, and at times exhibiting an umbrellalike expansion called the copulatory bursa. The most common roundworms are: Ascaris lumbricoides, hookworms, Trichuris trichiura, Enterobius vermicularis, Trichinella spiralis, and Wuchereria bancrofti.
1. *Ascaris lumbricoides*, the round or eel worm, probably is the most common parasite of man, especially children. They average about 6 inches in length

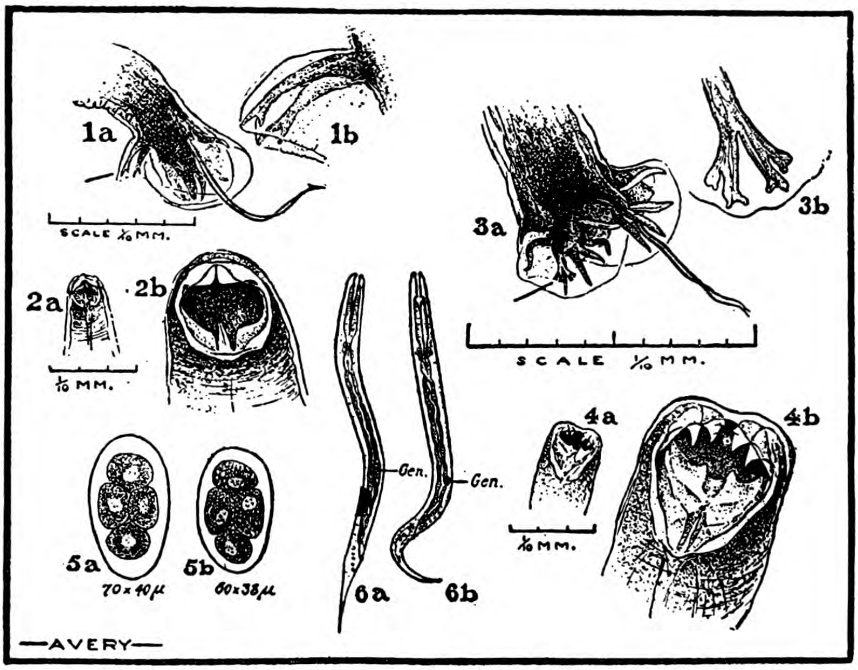

FIGURE 171.—1a, copulatory bursa of *Necator americanus*, showing the deep cleft dividing the branches of the dorsal ray and the bipartite tips of the branches; also showing the fusion of the spicules to terminate in a single barb. Scale 1/10 mm. 1b, Branches of dorsal ray magnified. 2a, the Buccal capsule of *N. americanus*. 2b, The same magnified 3a, Cop. bursa of *Ancylostoma duodenale,* showing shallow clefts between branches of the dorsal ray and the tridigitate terminations. Spicules hairlike. 3b, The dorsal ray magnified. 4a, The buccal capsule of *A. duodenale,* showing the much larger mouth opening and the prominent hooklike ventral teeth. 4b, The same magnified. 5a, Egg of *N. americanus*. 5b, Egg of *A. duodenale*. 6a, Rhabditiform larva of *Strongyloides* as seen in fresh fæces. 6b, Rhabditiform larva of hookworm in fæces 8 to 12 hours after passage of stool. (Stitt.)

and are grayish to reddish in color. An intermediate host is not required. Infection takes place through food or drink or by fingers of children who have been playing where soil pollution exists. The adults live in the intestine.
2. *Hookworms* (fig. 171). These roundworms are of considerable importance from a medical standpoint. Human infection comes almost entirely from two types of hookworms, *Ancylostoma duodenale*, the Old World species, and *Necator americanus*, which generally is called the New World species. They average about one-half inch in length. The males are distinguished from the females by their expanded posterior end. The large open mouth of the Old World hookworm has four claw-like teeth on the ventral side and two knob-like teeth

on the dorsal aspect; the New World hookworm has a smaller round mouth and the ventral teeth are replaced by plates, and it also has a prominent dorsal tooth projecting into the mouth cavity. Man is the definitive host and an intermediate host is not required. Infection takes place by larva in polluted soil penetrating the skin from where the larvæ make their way to the intestine, and there develop into adults. 3. *Trichuris trichiura,* usually called the whipworm on account of the thickened body resembling the handle and the narrow neck the lash, is one of the most common parasites in both temperate and tropical climates, and averages about 2 inches in length. It does not require an intermediate host. The diagnosis of the three roundworms described is

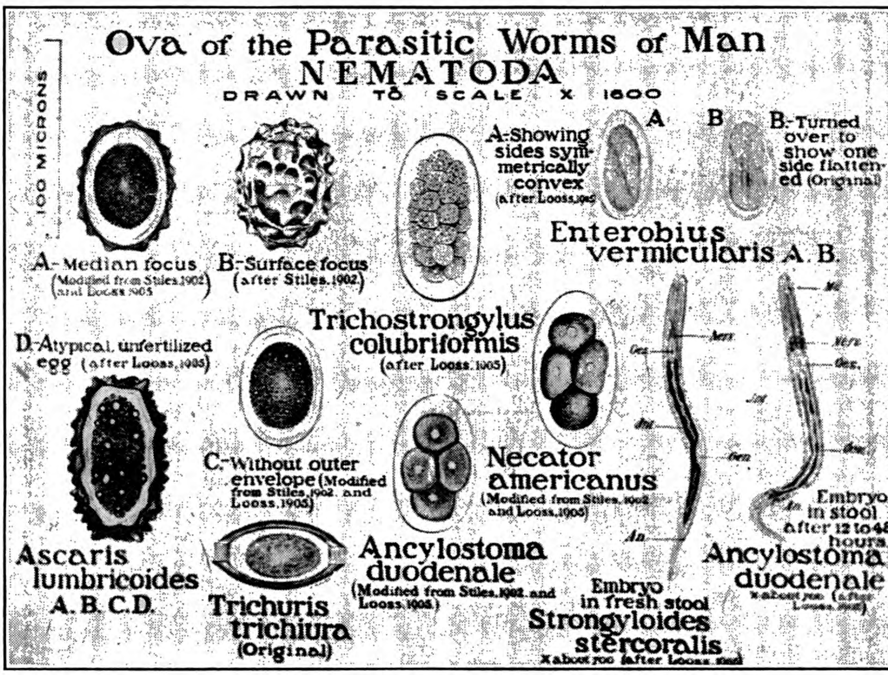

FIGURE 172.—Nematode ova. (Stitt.)

made by finding the adults or their ova (fig. 172) in the stools. 4. *Enterobius vermicularis,* a parasite commonly known as the pin or seat worm and found more frequently in children than in adults. The male is about one-sixteenth of an inch and the female about one-half inch in length. The male has an incurved tail with a single spicule and the female a long tapering tail. The female, loaded with eggs, wanders out of the rectum, and, as the result of scratching, the fingers become contaminated with the eggs, which may be carried to the mouth and cause a fresh infection, an intermediate host thus not being required. Diagnosis usually is made by examining the stools for the white, threadlike females, which usually are expelled after a purgative. 5. *Trichinella spiralis* is the cause of trichinosis. The adults live in the intestine and are about one-sixteenth of an inch in length. The female does not lay eggs, but gives off larvæ directly which wander to the muscles of the body. Man acts as the definitive host and hogs as the intermediate host, infection being contracted by eating insufficiently cooked pork. Diagnosis is made in the first 5 days of the disease by finding the adults in the stools, after that time by finding the larvæ in the blood or muscles. 6. *Wuchereria bancrofti* is the most important of filarial worms and causes an infection common in tropical

countries. The adult worms live in the lymphatics and are about 2 inches in length. The female normally does not lay eggs but gives off larvæ, which enter the blood stream. Characteristic of this parasite is the appearance of the larvæ in the blood stream only when the patient sleeps. Man is the definitive host, and the mosquito, especially the Culex quinquefaciatus, the intermediate host. It takes about 3 weeks for the larvæ to develop properly in the mosquito before they can infect another man. Diagnosis is made by the presence of the larvæ in the blood stream.

The ARTHROPODA is the other branch of animals which will be particularly discussed in this section. Of these, from a medical standpoint, interest centers in two classes only, the arachnids and the insects.

ARACHNIDA.—This class includes the *mites* and *ticks*, which differ from the insects in having a head and thorax fused together and possessing four pairs of legs instead of three, and the spiders. A common parasite belonging to this class is the *Sarcoptes scabei*, the human itch mite. This minute, whitish mite causes a skin disease known as *scabies*. The disease is brought about by the female mite burrowing into the skin, where eggs are laid, from which come young mites that are to spread the infection. Diagnosis is made by examining the skin scrapings under the microscope for the presence of the mites or their eggs.

The tick family of arachnids is of great and increasing importance medically. It was through proving the tick transmitted a disease of cattle in Texas that the zoological principle of transmission of diseases by means of arthropod hosts was established. Ticks are much larger than mites, readily being seen by the unaided eye. They are wholly parasitic in their habits. Some of them live on their host practically all their lives, dropping to the ground to deposit their eggs. Among the ticks of importance are: *Ornithodoros moubata* and *Dermacentor andersoni* (fig. 173). 1. *Ornithodoros moubata* has a hard, rough skin, and on looking down on its back the head cannot be seen. It lives in the huts of the natives of Africa and has habits very similar to the bedbug, feeding at night and hiding during the day. It transmits a protozoan, *Borrelia duttoni*, which causes South African tick fever. 2. *Dermacentor andersoni.* A tick found in the western part of the United States which can be roughly distinguished from the *O. moubata* on account of its smooth skin and the head parts projecting beyond its body outline. It transmits the spotted fever of the Rocky Mountains. The dog tick, *D. variabilis*, also transmits Rocky Mountain spotted fever which is due to the virus often called *Dermacentroxenus rickettsi.*

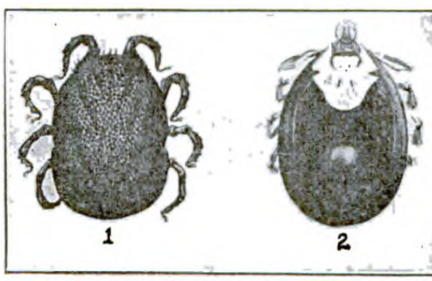

FIGURE 173. Ticks: 1, *Ornithodoros moubata;* 2, *Dermacentor andersoni.* (Stitt.)

Of the spiders, *Lactrodectus mactans*, the "black widow" or hour glass spider, is important because of her dangerous bite. She lives in outbuildings and is recognized by the black color and deep orange hour-glass shaped spot on the ventral abdomen. About 30 minutes after the bite excruciating pains are felt in various parts of the body particularly of the abdomen with marked rigidity of the muscles.

INSECTA.—In this class are the mosquitoes, the fleas, flies, lice, and bedbugs. These parasites have three well-marked divisions of body: Head, thorax, and abdomen; three pairs of legs and one pair of antennæ.

The *Culicidæ* or mosquitoes are of the greatest importance medically, not only from their influence upon health in general by reason of interference with sleep and possibly from direct transmission of disease but, more specifically, because they are the only means by which it at present appears possible to bring about infection with such diseases as malaria, yellow fever, filariasis, and dengue. In the life history of mosquitoes (fig. 174) the female lays eggs in water or in places where water is apt to collect; otherwise they will not hatch. In from 1 to 4 days a larva or wriggler emerges and comes to the surface to breathe. These larvæ are of two types—the siphonate and the asiphonate. The siphonate are so called on account of having a breathing

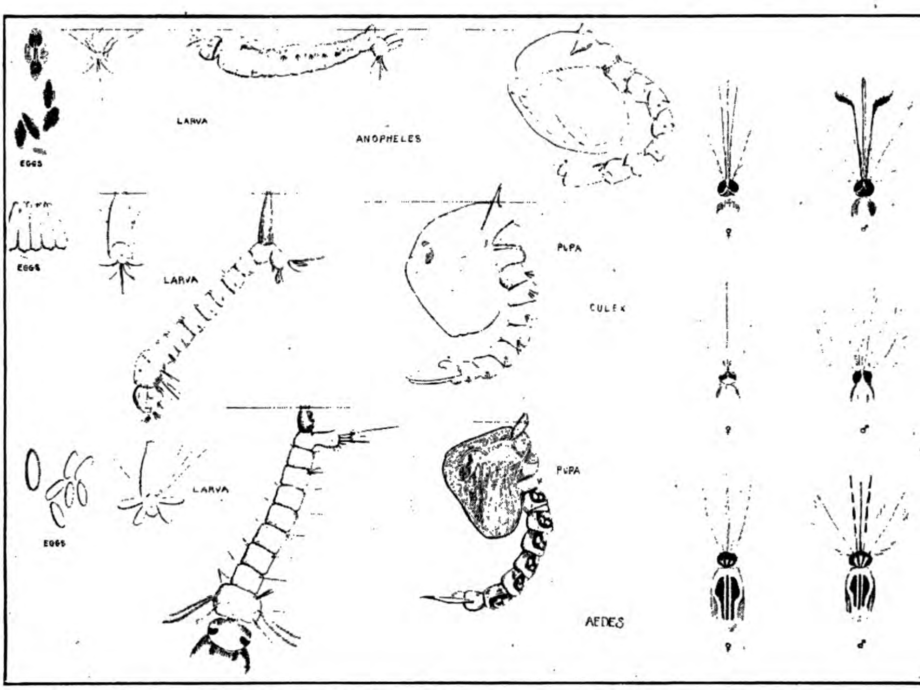

FIGURE 174.—Life cycle of the *Anopheles, Culex,* and *Aëdes* mosquitoes. (Stitt.)

tube projecting from the tail end of the abdomen. When seen at rest this tube projects above the surface of the water and the head end of the larva hangs down at an angle. The larva of the mosquito (*Culex*) that transmits filariasis has a long, narrow siphon, and the larva of the yellow-fever mosquito (*Aëdes*) has a short, barrel-shaped siphon. The asiphonate do not have this tube, but possess breathing slits and at rest float parallel to the surface of the water. This is the larva of the mosquito (*Anopheles*) that transmits malaria. This larva has another characteristic feature, namely, fan-shaped hairs on each side of its abdominal segments, called palmate hairs. After a period of about a week the larva enters a nongrowing, nonfeeding stage, called the pupa or nymph, from which in about 3 days the adult mosquito releases itself and flies away.

It is desirable that the anatomical characteristics of mosquitoes be known to those who may have to examine them (Fig. 175). In examining an adult mosquito it will be noted that there are three divisions of the body: Head, thorax, and abdomen. The head shows a stout projection, called the proboscis, which contains the biting parts. In mosquitoes of medical interest

this proboscis is long and straight. In males the biting parts are not strong enough to pierce the human skin; thus it is known that only the female bites. On each side of the proboscis are the palps, or sensory organs, and to the

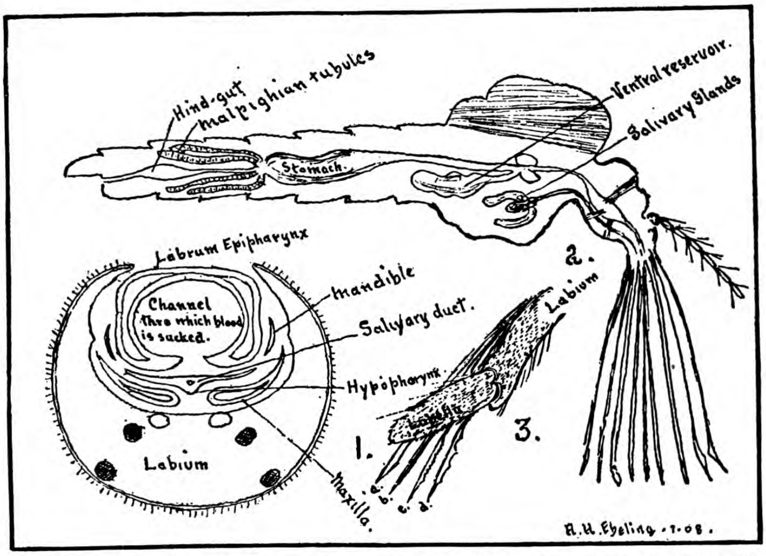

FIGURE 175.—Anatomy of mosquito: 1, Cross section of proboscis; 2, anatomy of mosquito, longitudinal section; 3, tip of proboscis; *a*, labium epipharynx; *b*, hypopharynx; *c*, mandible; *d*, maxilla. (Stitt.)

outer side of these are the antennæ, or feelers. The male mosquitoes can be distinguished by the heavily feathered antennæ. The thorax supports the three pairs of legs and one pair of wings. The wings have a characteristic arrangement of the veins and show scales. Mosquito-like insects do not have scales on their wings. The abdomen has nine segments, and on the last segment of the male are claspers.

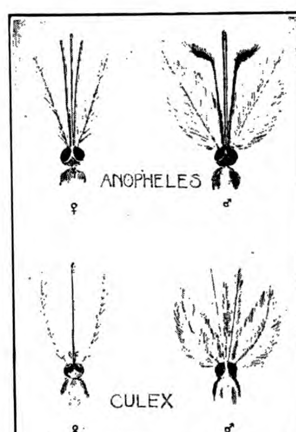

FIGURE 176.—Mosquito heads showing heavily feathered male antenna and the long palps of the *Anopheles* female and the short palps of the *Culex* female. (Stitt.)

While there are about a dozen varieties or genera of mosquitoes, from a medical standpoint interest centers in but three of these genera, the *Anopheles*, the malaria mosquito; the *Aëdes*, the yellow-fever mosquito; and the *Culex*, the filaria mosquito. To definitely differentiate these mosquitoes it is necessary to use elaborate keys and tables. But to tell whether a mosquito is a probable malaria or yellow-fever transmitter is a comparatively easy matter. The first step is to obtain a female, remembering that the antennæ of the female are sparsely and not heavily feathered, as in the case of the male. The males also show claspers on tail end of abdomen. Having secured a female, note the length of the palps (Fig. 176). If they are as long as the proboscis and clubbed and the wings of the mosquito are spotted, it is an *Anopheles*. If the palps are not as long as the proboscis and it is a small, black mosquito with silver or white markings on the back of its thorax it is an *Aëdes*. A mosquito with short palps, without these markings, is probably a *Culex*.

The *Siphonaptera* or *fleas* (fig. 177) have come into prominence on account of their importance in connection with the spread of plague. In this case the transmission of the disease is mechanical; that is, by biting and depositing fæcal matter containing the bacillus in the wound. The bacillus causing the disease is merely carried without change in the flea host. This is in contrast to what is known as a biological transmission, such as in the case of malaria and yellow fever, where the protozoan that causes these diseases undergoes a change in the mosquito host.

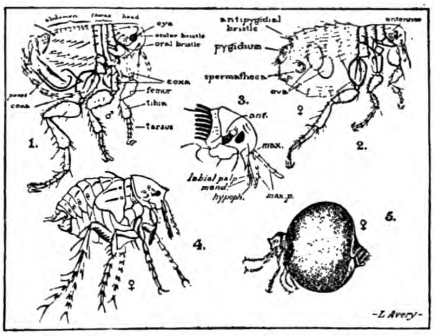

FIGURE 177.—Types of fleas and jigger: 1 and 2, male and female *Xenopsylla cheopsis*; 3, head of *Ceratophyllus*: 4 and 5, male and egg-distended female of *Tunga penetrans*. (Stitt.)

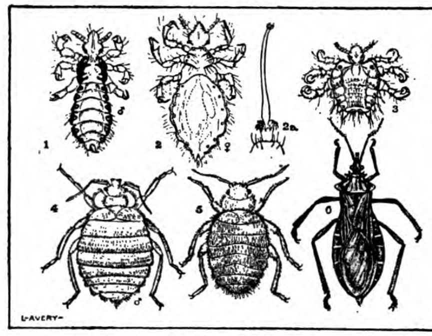

FIGURE 178.—1. *Pediculus humanus* var. *humanus*. 2. *Pediculus humanus* var. *corporis*. 2a. Protruded rostrum of *Pediculus*. 3. *Phthirius pubis*. 4. *Cimex lectularius*. 5. *Cimex rotundatus*. 6. *Triatoma megista*. (Stitt.)

The *Pediculidæ* or *lice* (fig. 178) are of three varieties. The one living on the head is called the *Pediculus humanus* var. *humanus*, the one on the body the *Pediculus humanus* var. *corporis*, and the one living in the hairy region about the pubis, popularly known as crab louse, the *Phthirius pubis*. The body louse lays its eggs in the seams of the under-clothing and is important on account of transmitting European relapsing fever, trench fever, and typhus. The relapsing fever is due to a spiral shaped organism called *Borrelia recurrentis*. Trench fever and typhus are caused by minute, chromatin staining, lanceolate organisms called *Rickettsia*.

Flies.—The fly best known is the ordinary house fly *Musca domestica*. Its mouth parts are fitted for sucking and not biting. Its food must be in a liquid or semisolid state before it can be sucked up into its stomach. If it wishes to feed on any solid substance, such as sugar, it first pours out saliva to liquefy it. Many people think that the house fly can bite, but careful examination of such a biting fly will usually show it to be the stable fly, *Stomoxys calcitrans*.

Perhaps the most dangerous parts of a fly are the pads or pulvillæ on its feet. By means of these it can carry much filth frequently containing bacteria which cause typhoid fever and other diseases.

Another important fly belonging to the same family as the house fly is the tsetse fly (*Glossina palpalis*), which transmits the *Trypanosoma gambiense*, the cause of African sleeping sickness. Some flies, like the flesh fly (*Sarcophaga carnaria*), can cause considerable discomfort by laying their eggs in wounds or cavities like the nose, ear, etc., their eggs developing into larvæ or maggots.

Following is a list of important diseases due to animal parasites:

Parasite	Disease
Entamœba histolytica	Amœbic dysentery.
Trypanosoma gambiense	African sleeping sickness.
Plasmodia malariæ	Malaria.
Schistosoma japonicum	Japanese schistosomiasis.
Tænia saginata	Beef tapeworm.
Tænia solium	Pork tapeworm.
Wuchereria bancrofti	Filariasis.
Diphyllobothrium latum	Fish tapeworm.
Hymenolepis nana	Dwarf tapeworm.
Necator americanus	Hookworm.
Sarcoptes scabiei	Itch or scabies.
Tunga penetrans	Sand flea or chigger itch.
Ascaris lumbricoides	Ascariasis.
Trichinella spiralis	Trichinosis.

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Section 10.—PHYSICAL THERAPY

Physical therapy is the application of physical energy in the treatment of diseases, injuries, and new growths. Physical therapy has become such an important part of many medical and surgical treatments that it should always be under the direction of a medical officer who has the training necessary for diagnosis, proper selection of modalities, and correlation of treatment with the other forms of medical and surgical prescriptions that may be necessary. For convenience physical methods may be classified as *mechanotherapy*, *hydrotherapy*, *light therapy*, and *electrotherapy*.

MECHANOTHERAPY

This method of applying physical energy in the treatment of disease involves especially the use of movement and is sometimes called the therapy of movement. Massage and exercise are two ways of obtaining movement in treating disease.

Massage.

This is one of the oldest and most useful methods of physical treatment. It is a therapeutic manipulation of the soft tissues and is best mastered by manual demonstration and long practice. In massage there are three main varieties of movement which are used singly or in combination.

To prevent causing unnecessary discomfort or pain to the patient the use of a lubricant such as cocoa butter, a bland oil, or an appropriate liniment is advisable.

STROKING, or effleurage, is fundamental and consists of even and uniform pressure exerted along a certain path. The palm of the radial side of the hand is used on large surfaces, the thumbs in areas close to bone, and the

finger tips around small joints. The hands must be relaxed to follow the body contours, and should be warm, dry and clean, always kept in contact with the parts and always returned lightly to the starting point before changing direction. Stroking is always in direction of the venous flow and should be slow and rhythmic, about 15 strokes per minute. The patient's muscles must be relaxed. In deep stroking, the pressure is deep but not heavy, and 4 or 5 strokes a minute are used to promote fluid flow. Fifteen to thirty light strokes per minute are used for sedative effect.

COMPRESSION may be effected by kneading or friction. In KNEADING, the skin and subcutaneous tissue is picked up between the thumb and fingers, with pressure short of causing pain. It is best accomplished by the two hands opposed, as picking up small muscles between the finger tips, or with the finger tips against the palm rolling the muscles under them against the bone, as in the large muscle masses of the thigh and leg. The movement is always gradual, from the periphery inward. While pressure is being given, the skin is moved with the hand, and the part squeezed in the direction of the venous flow. The hand is never entirely removed from the part. Treatment is from the proximal end, distally in a muscle group but each individual motion is in the direction of venous flow. Kneading stretches retracted muscles and tendons, adhesions, and removes waste products from the muscle. FRICTION is a circular form of kneading with pressure against underlying tissues that cannot be grasped. The tips of the thumbs, working in opposite directions, are used in small areas; the tips of the fingers around joints and the entire hand over large areas, as the back and thigh. It should always be preceded or followed by stroking, and carried out in the same general direction. Friction is used to free adherent skin, and to loosen scars and adhesions of deeper parts. (Mechanical vibration is also used.)

PERCUSSION, or tapotement, is the most stimulating form of massage and the most apt to be overzealously employed. SLAPPING is accomplished with the palmar surfaces of the fingers as quick alternating strokes, with the wrist relaxed and the fingers immediately rebounding. It is a powerful stimulation to the skin capillaries and nerve endings as well as to the entire nervous system. For HACKING, the ulnar side of the hand and little finger is used to make rapid chopping motions, from the wrist, either light or heavy. Hacking is used for its effect on the deep structures, relaxing muscle spasm, breaking up organized exudates, and stimulating deep muscles. In TAPPING the tips of the fingers are used.

In general, massage is used to aid lymphatic and venous flow, to loosen adherent scar tissue and stretch contractures, for its sedative effect, and to increase metabolism generally, to improve muscle tone, strength, and relieve spasm, and to improve skin function and tone. Massage should be given in a warm (70° F. to 75° F.) light room, with the patient comfortable, preferably reclining. In addition to those previously mentioned, talc is also a satisfactory lubricant, and oil should always be used over scar tissue. Warm the area by radiant heat or hot baths before massage. When used alone 10 to 15 minutes is the usual time, but 5 to 10 minutes is enough when other treatment is used in connection. Use massage daily in acute or painful conditions.

CLINICAL USES OF MASSAGE.—Recent injuries, fractures, sprains, dislocations, stiff (not ankylosed) joints, arthritis, rheumatic conditions, gastro-intestinal atony, chronic constipation, flaccid and spastic paralysis are conditions which may be benefitted by massage. In central nervous conditions massage is used for its soothing effect. In chronic cardiac decompensation œdema may be decreased and the heart load lessened by cautious general stroking and gentle

kneading. Massage may be used in convalescence for its general stimulative effect.

The type of massage and the time the procedures are to be used is determined by the medical officer.

CONTRAINDICATIONS TO MASSAGE.—Massage is not to be used in the following conditions: Acute skin diseases, skin and subcutaneous infections, over pigmented moles, wounds, tumorous swellings, acute phlebitis and thrombosis, infectious arthritis, undrained osteomyelitis, inflammatory processes in the abdomen, gastric or duodenal ulcers, acute neuritis, heart diseases, unless ordered by the medical officer, or varicose veins. Massage may be used around varicose veins.

Exercise.

In general the value of exercise in maintaining health is well recognized. Schools make provision for systematized exercise under the direction of teachers specially trained in physical education. A large part of the adult population has become acquainted with various "setting up exercises." The Navy and military organizations employ calisthenics in their drill schedule. They also use competitive games and sports for their physical training as well as for the beneficial effect on morale. It is obviously better to force deep inspiration by activity, than by artifical deep breathing.

There are four general types of exercises used in therapeutics.

PASSIVE EXERCISES are those done wholly by the operator, the weight of the patient's body, or by utilizing some other external force.

ASSISTIVE EXERCISES are performed as far as possible by the patient, assisted by the operator.

ACTIVE EXERCISES are movements executed exclusively by the patient.

RESISTIVE EXERCISES are done by the patient, opposed by friction, gravity, weights, the operator's or the patient's own physiologically opposing set of muscles.

In nearly all faulty postures, not due to defects in the skeleton, the following factors are present: 1. Lack of balance in power of opposing sets of muscles; 2. Gradual shortening of the stronger set of muscles, and lengthening of the weaker set; 3. Gradual lessening in the flexibility and range of motion in the joints moved by affected muscles; and 4. A dulling of "muscle and joint sense" which causes the awareness of malposition.

Every exercise regime must be aimed at correction of each of these factors, by strengthening weak sets of muscles, stretching those contracted, maintaining and increasing full flexibility, and developing the muscle sense. And lastly, development of the general physique is essential.

Before starting treatment, all causes that can should be corrected or removed, as defective hearing and eyesight, improper sitting posture, pain, habitual unilateral carrying methods, improperly applied clothing and supports, nutritional defects, and deficient exercise.

Therapeutic exercise is often preceded by the use of radiant light, short wave diathermy, mild sinusoidal current, and massage to warm and prepare the part for exercise.

CLINICAL USES OF EXERCISE.—Many morbid conditions are benefitted by exercise, a few of such conditions being: Hæmiplegia, cerebral degeneration, encephalitis lethargica (sleeping sickness), lesions of the spinal cord, injuries of the peripheral nerves, fractures, sprains, valvular heart disease, functional cardiac disturbrances, falling of abdominal organs (visceroptosis), constipation. tuberculosis, emphysema, and curvatures of the spine. The use of exercise

in any of these or in other conditions must always be as ordered by a medical officer.

For information as to the programs of exercises to be used in the treatment of various disease conditions reference may be had to any standard text on Physical Therapy.

HYDROTHERAPY

Hydrotherapy is a term used to designate the therapeutic procedures related to the external application of water to the body. Many of these measures are very simple and in common practice, and can be applied without special apparatus, with positive benefits to the patient.

The outer layer of the human skin is essentially a waterproof covering under which is the true skin containing blood vessels and nerve endings, and still deeper the sebaceous and sweat glands. The effect of hydriatric measures consists of the reaction in the skin, and in the organs reflexly connected with it. Mechanical force adds to the effect of any hydriatric application.

Water is applied in the treatment of disease at different temperatures with different reactions for each. The application of tepid water, 85° F. to 95° F., causes relaxation. The short application of cold water, 40° F. to 65° F., causes the skin to pale, the small blood vessels to constrict, and the muscular tissues to contract. This is followed immediately by relaxation and increased blood flow. There is deep inhalation at the time of application. With reaction the pulse rate slows and the heart is more efficient. A sense of well-being follows. This must not be used in persons of low vitality. The long application of cold water causes continued contraction of blood vessels, followed by total or partial relaxation and paralysis (a severe example is frostbite). A short, intense application of hot water, 100° F. to 110° F., causes the same immediate reaction as cold, but the primary effect subsides quicker. The resulting hyperæmia is more widespread and is atonic in character. The local and general effect of continued local application of hot water corresponds to radiant heat.

COMPRESSES are folded linen cloths placed over the part to be treated. They are slightly wrung out of water at the temperature desired, and held in position by dry flannel bandages. The size depends on the area to be treated and the temperature on the effect desired.

COLD COMPRESSES cause contraction of the peripheral vessels and are used for immediate relief of recent injuries, in the early stages of inflammation, and for combating swelling, redness, and pain. They may be renewed every half hour.

In cerebral congestion (headache) apply cold compresses to the forehead; in heart disorders they may be applied præcordially.

A *stimulating compress* is a cold compress under several layers of flannel. It causes first a vasoconstriction, then, with reaction, vasodilatation; the bandage dries in 1 to 4 hours. It is used over the throat in sore throat, laryngitis, and tonsillitis, over the chest in all pulmonary conditions, and over the abdomen in gall-bladder disease.

HOT COMPRESSES are applied in the same manner as cold ones but at 105° F. to 115° F. In 1 to 2 hours they will produce intense hyperæmia, soften inflammatory congestion, and relieve pain and spasm.

FULL COLD WET PACKS are used for their sedative effect and as antipyretics. The temperature of the water should be between 60° F. and 70° F.

FULL HOT WET PACKS are used to increase elimination. The temperature of the water should be between 110° F. and 115° F.

Technique for applying either pack.—Spread rubber sheet over the bed and a blanket over the rubber sheet. Immerse a cotton sheet in the water at the temperature that has been ordered and wring out. Open sheet and spread over the blanket. Patient now lies flat on his back on this sheet.

Have the patient raise his arms above his head. Fold one-half of the sheet closely over patient's body and high under his arms. Work fast. Have patient lower his arms to his sides. Wrap the remaining half of the wet sheet around the patient with the upper edge surrounding the neck. Press a fold down between the legs and feet and fold the lower end under the heels. Be sure the sheet clings snugly to the body everywhere.

Fold the blanket smoothly around the patient and cover with an extra blanket on top. If feet will not warm up apply a hot water bottle to them. Patient may stay in the pack 45 minutes to 1 hour.

ABLUTIONS, FULL.—Pouring water over the entire body or part of it is a mild procedure to apply thermal stimuli. The patient sits in a tub and water at 60° F. to 70° F. is poured over the back and chest. The procedure should be short and not used in patients with high blood pressure.

PARTIAL OR TOWEL BATH.—The patient is in bed, covered with sheet and blanket. Towels at 65° F. are applied in succession over arms and legs, chest and back. Each towel is rubbed until it feels warm. Each area is dried, covered, and the next area then treated. Do not use over 5 minutes. This bath is used on febrile and elderly patients and gives a mild stimulating effect.

SHEET BATH.—The patient, on a rubber sheet, is wrapped in a sheet wrung out of 50° F. to 80° F. water. He is then rubbed until the sheet feels warm (2–3 minutes), quickly dried and put to bed, well covered. This bath stimulates vasomotor and nervous tone.

DRIP SHEET.—The patient stands with a wet towel on his head, and a sheet wrapped around him. As the sheet becomes warm attendants pour water over it at a temperature of 5° F. lower than the first used. It is a vigorous general nervous stimulant and antipyretic after 15 minutes. It may overtax a patient's reactive powers, so caution must be used.

BATHS.—A short COLD BATH is given a few seconds to 2 minutes in a tub of water at 60° F. to 65° F. The skin is rubbed and as soon as dried the patient exercises or is given a massage. Cold baths must not be used in hypertension, weak heart, or hæmorrhagic states. A cold bath is a tonic procedure.

CONTINUOUS TEPID BATHS.—Patient's body is greased with lanolin or vaseline. He is then placed in a tub of water at 94° F. to 98° F., suspended in a hammock-like arrangement. Rubber pillows support the head and buttocks. The water is kept at the desired temperature, preferably by thermostatic valves. It is used from a few hours to days or weeks to quiet nervous conditions, treat suppurating wounds, burns, and extensive skin lesions.

HOT BATHS are full tub baths given at temperatures from 100° F. to 108°F. Start at body temperature and quickly raise the temperature after the patient is immersed to the chin. Continue for from 10 to 20 minutes, dry the patient and give an alcohol rub. Hot baths increase elimination, metabolism, and give some relief to muscle spasms. They were often used in arthritis and rheumatoid conditions until the electric light cabinet superseded it in most institutions.

HYPERPYREXIA BATHS.—Patients are immersed in a tub of water at 110° F. (starting at body temperature). Ice is applied to the head and neck. The body temperature may reach 104° F. in 20 minutes. The water is then lowered to 105° F. and the body temperature is kept at this degree for 45 minutes to 1 hour. Patient may require considerable nursing. Reduce temperature to

normal by cooling the bath and follow with rest in bed. Baths are to be administered 1 to 3 times a week for 10 to 20 times.

HIP AND SITZ BATHS.—A local bath that may be given in any tub not over a foot high. In most institutions, specially built tubs support the back and arms. The water should cover the umbilicus.

Short cold sitz baths with water at 65° F., given for a few minutes with vigorous friction of the abdomen, result in a strong stimulation of the abdominal muscles and tissues.

The *hot sitz bath* with water at from 110° F. to 115° F., is given for 15 minutes. They cause relaxation of abdominal pain and spasms and are also used for prostatitis and hæmorrhoids.

CONTRAST BATHS cause an intense vasomotor stimulation of the hands or feet. The part to be treated is placed in hot water at from 105° F. to 115° F. for 1 minute; then in cold water for 1 minute, and repeated 7 to 15 times, followed with massage and motion. The part should be immersed in hot water last. These baths are used in circulatory disturbances of the extremities; chilblains, trench feet, wounds, scars, amputation stumps, and foot disabilities.

For shoulders, knees, and other parts of the body contrast baths may be given by using a hot spray for 5 minutes and then a cold spray for 1 minute; then a hot spray for 1 minute and cold spray for 1 minute. Continue changing at 1 minute intervals for 15 to 20 minutes, and always end with hot spray.

PARAFFIN BATHS are used to apply intense local heating to the skin. The skin is covered with hot molten paraffin and soon becomes encased in a solid nonconducting cast, which keeps up the temperature of underlying parts for a long time.

Method of use.—Obtain about 3 or 4 pounds of paraffin, or "jelly wax" as it is commonly called, and melt it in the top of a double boiler until it is liquid. Then let it cool until a thin, white coating appears on the top when it is ready for use.

When applied to the hands, the hands are dipped in and out, without moving the fingers, until several coatings are applied. Then let the hands remain in the wax for 20 minutes, take them out and peel off the wax.

To apply to other parts of the body (knees, shoulders, elbows, back, etc.) obtain a wooden paddle or a wooden cooking spoon. Wrap several thicknesses of cloth around it, tying them on. Dip this in the wax and paint a coat over the entire area to be treated, until the part is completely covered. Then paint 10 to 12 coatings on top of this. Cover with a towel or blanket and leave on for 20 minutes. Then peel off the paraffin and the part is ready for further treatment. Paraffin baths are useful in after treatment of fractures of the bones of the wrist and hands, stiffness of joints following lacerations or infections, scar tissue restricting motions of joints and tendons, weakness or stiffness of hands secondary to nerve lesions associated with fractures, or other lesions of nerve trunks.

HYDROKINETIC MEASURES consist of douches and showers. SHOWERS are in common use by many people and have a strongly invigorating effect, but must be used cautiously in the weak and ill. DOUCHES are administered from a control table (fig. 179), usually with two nozzles and appropriate mixing valves for temperature control. Valves for pressure control and thermometers and pressure gauges are on each nozzle.

Rain showers (from overhead) affect the shoulders and head. The circular or needle douche is arranged with outlets around the shower cabinet so that by turning, the entire body is in contact with many fine jets of water. This shower can be used at constant temperatures, or by alternating hot and cold several

times. Is mildly stimulant to circulation and metabolism and is of value in nervous and functional heart conditions.

Jet douches are applied from the control table, with a solid stream of water. In *fan douches* the tip of the finger is held over the nozzle tip to fan the stream, thus creating mechanical stimulation. A constant hot or cold douche or an alternating hot and cold douche (*Scotch douche*) is used with the patient facing the table, 10 to 12 feet away. The jet is applied slowly from the feet up to the shoulders and down again, with the same application over the back, for 2 to 4 minutes; the patient should then quickly dry and dress. Allow reaction to occur and repeat several times. Do not overtax patient's reactive power.

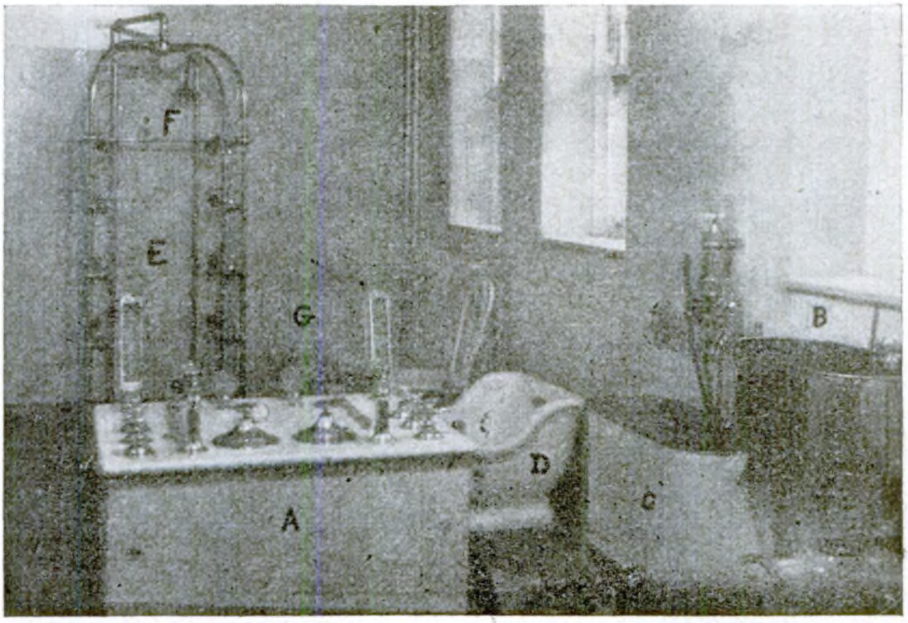

FIGURE 179.—Hydrotherapy apparatus showing: *a*, control table; *b*, arm whirlpool; *c*, leg whirlpool; *d*, sitz bath; *e*, needle spray; *f*, shower.

WHIRLPOOL BATHS are baths in which water at 110° F. to 115° F. is kept in agitation in a vessel which will hold an arm or leg. This has the advantages of heat and the gentle mechanical effect of whirling water. In 15 to 45 minutes the skin becomes pink, inflammatory induration is softened, pain and spasm relieved, repair of wounds stimulated, and the removal of necrosed tissue and pus speeded up.

They are used for the stiffness, pain, and sluggish skin circulation following fractures as soon as immobilization can be removed. Painful scars, adhesions, peripheral nerve injuries, some forms of arthritis, indolent chronic suppurating wounds, painful stumps, weak and painful feet respond very well to this treatment. They are used as a preparation for massage and electrical therapy.

THERAPEUTIC POOLS AND TANKS.—Under-water medical gymnastic exercises take advantage of the buoyancy of water for the reeducation of feeble and flabby muscles. The temperature of the water is also beneficial, and in outdoor pools the sun and fresh air are of aid. Salt will increase the buoyancy. Their greatest use is in treating victims of poliomyelitis, but it is also used in spastic paralysis, multiple sclerosis, chronic arthritis, post-operative bone cases (especially back and hip cases), scoliosis and postural spine deformities. The usual

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temperatures are 97° F. to 100° F. for spastic states and sensitive muscles, and 86° F. to 92° F. for other chronic conditions.

A large bath tub may be used for children and special tanks are often constructed. The usual hospital pool is 10 x 15 feet with a depth of 2 to 4½ feet. The floor is of non-skid material; easy steps are necessary and often hoisting devices are provided. Hand holds, chairs, and various floating supports are necessary.

LIGHT THERAPY AND ELECTROTHERAPY

The methods used in light therapy and electrotherapy may be considered simply as the application of energy which is obtained from a number of sources and has various wave lengths, with corresponding frequencies of wave oscillation. The various wave lengths vary markedly in their effects on the human body and are measured usually in Angstrom units (abbreviated A°, or A. U.) the length of one unit being 1/10,000,000 millimeter. The electromagnetic spectrum extends from the cosmic rays which have a wave length of 0.001 to 0.01 A. U., are generated in intrastellar space and are of no known therapeutic use, through the gamma rays of radium (0.01 to 1.4 A. U.) X-rays, ultraviolet, visible light, infrared or heat rays, to the long and short Hertzian waves. The latter waves include the length used in diathermy (300 meters), short wave diathermy (30 to 3 meters), and the extremely long waves used in radio transmission.

Light therapy consists of the therapeutic application of radiant energy. Radiation is the process by which energy is propagated through space. A light ray consists of an enormously large number of exceedingly small entities traveling through space at a speed of 186,000 miles per second.

The clinician tests the length of the waves he uses by their skin effect, and for other methods he relies on the manufacturer or physicist.

LUMINOUS SOURCES.—Infrared and luminous radiations are long wave, or far infrared rays, such as are radiated from hot-water bottles and electric pads and do not penetrate deeper than 3 mm. in the skin, and short wave, or near infrared rays, which are supplied by the sun, carbon arc lamps, incandescent lamps, and specially built infrared generators, and penetrate 10 to 30 mm. to the subcutaneous tissue. The most common luminous sources are incandescent filament radiators, electric light bulbs with tungsten or carbon arc filaments, with reflectors. A wattage of from 150 to 1,500 may be used but the penetration is the same. These lamps produce 95 per cent infrared rays, 4.8 per cent visible radiation, and 0.1 per cent ultraviolet rays, the latter being absorbed by the glass.

"Bakers" are provided with several small (60 watt electric) light bulbs in cradles, and if necessary can be built by any tinsmith.

NONLUMINOUS SOURCES.—A heating element mounted in the center of a portable reflector is heated by an electric current to a dull red, and the reflector distributes heat on the body evenly. They are similar to bathroom heaters and are only skin warmers.

The local effect of light therapy is nearly immediate, and shows as a reddening of the skin which lasts from 10 minutes to an hour. The active hyperæmia results in better circulation, better nutrition, increased removal of wastes and increased resistance to infection. Overdoses cause deep burns. Small amounts are sedative, large amounts are counterirritant. The effects of general irradiation are profuse perspiration, rise in pulse rate, lowering of blood pressure, increased respiration, increased elimination from kidneys, and sedation.

CLINICAL USES.—Light therapy is beneficial in contusions, muscular sprains, traumatic synovitis, sprains and dislocations, fractures in accessible locations (not in the first few hours), arthritis, rheumatoid conditions, neuritis, neuralgia,

acute, subacute, and chronic catarrhal conditions in accessible areas, as conjunctivitis, sinusitis, nonsuppurative otitis media, and bronchitis. If used early in head colds it will often abort them. It is also of value in folliculitis and furunculosis, and to warm antiseptic dressings in cellulitis, etc. For this purpose it has the advantage of even heat, no pressure, and does not disturb the patient. Light therapy is used to warm the skin before diathermy, galvanism, massage, etc.

TECHNIQUE.—The patient is made comfortable and the generator directed over the part to be treated, at a comfortable distance, usually 2 to 3 feet. A 10-minute treatment is given to warm the skin, one-half to 1 hour is used for other treatments. Repeat daily or oftener, depending upon acuteness of cases and the progress.

PRECAUTIONS.—Never make the patient uncomfortable. Use 1½ times the normal distance for anæsthetic areas.

GENERAL HEAT RADIATION is used for selected cases of arthritis, nephritis, early active sclerosis, obesity and toxæmias, and often in combination with hydrotherapy.

ELECTRIC LIGHT BATHS.—A wooden cabinet, large enough for a patient to sit in with the head protruding, containing a number of light bulbs is used. The patient is undressed, seated, the box closed, and the lights turned on. An ice bag is applied to the head. The patient is never left alone, and the treatment is stopped if he becomes faint. For tonic treatments use 5 to 8 minutes; for eliminative, use 8 to 15 minutes and give water with salt to replace that lost by perspiration. Follow with a tepid shower. For bed patients, a large heat cradle may be used.

ULTRAVIOLET RADIATION.—The chief natural source of ultraviolet radiation is the sun. Of artificial sources the electric arcs between electrodes of metal, of carbon, and of mercury in quartz are used. The range of radiant energy designated ultraviolet is from 3,900 to 1,800 A. U. and is divided into "long ultraviolet" rays extending to 2,900 A. U., and short ultraviolet rays of 2,900 to 1,800 A. U. Sunlight contains less of the shorter rays. Quartz permits the passage of ultraviolet rays to 1,800 A. U., air up to 1,850 A. U., but dirt, smoke and dust filter out more. Ordinary window glass only permits passage of waves over 3,200 A. U. Human skin stops all ultraviolet rays, and even paper-thin clothing arrests most of the radiation.

The biological effects of sunlight are to increase the regeneration of red blood cells, to stimulate the formation of white blood cells, to increase resistance to some infections, to increase the calcium and phosphorus content of the blood serum, and to stimulate all metabolic processes.

CLINICAL USES OF GENERAL IRRADIATION.—The range of about 3,000 A. U. is curative in rickets. It is useful in bone and joint, lymph node, and genito-urinary tuberculosis, and as an adjunct to the treatment of general debility, secondary anæmia, convalescence, chronic bronchitis, asthma, and selected cases of neurasthenia.

Local irradiation is most nearly specific in lupus vulgaris and erysipelas. It is of value in many dermatoses, sluggish healing wounds, indolent ulcers and chronic osteomyelitis. Also in the treatment of chronic catarrhal conditions of the upper respiratory tract.

Sterilization of infected areas in carriers of cerebrospinal fever and diphtheria is often obtained after treatment with quartz rod applicators.

CONTRAINDICATIONS.—Ultraviolet irradiation is dangerous in active pulmonary tuberculosis, advanced cachexia, heart diseases with failure in compensation, advanced arterio-sclerosis, and gross renal or hepatic insufficiency. Annoying skin and general reactions may occur in diabetic and hyperthyroid

patients, and a generalized dermatitis as a rule is a contraindication. Photosensitization is a condition in which certain drugs, endocrine products, and heavy metals in the blood increase the effects of radiation. Check such cases with a subminimal application first.

HELIOTHERAPY.—Usually sunlight contains 60 per cent infrared and 40 per cent invisible and ultraviolet radiation (never below 2,900 A. U.). At higher altitudes the ultraviolet increases at the expense of the infrared. The season, climatic conditions, and hour of the day influence the amount of ultraviolet radiations reaching the earth. The greatest antirachitic effect is produced in the summer at noon. The effects of heliotherapy are produced by the blending of infrared, luminous, and ultraviolet radiations, as well as the usual nursing care used. The sun rays produce a pigmentation of the skin, an increase in general tone of muscle and skin, and a general euphoria with a lessening of pain and fatigue.

TECHNIQUE.—Heliotherapy can be practiced anywhere, except that sufficient sunshine and clearness of atmosphere are prerequisites. The best hours in the summer are from 7 to 11 and in winter from 10 to 2. On the first day expose the feet 5 minutes; on the second day expose legs 5 minutes and the feet 10 minutes, and by similar exposures include the whole front of the body in 5 days. Then on the sixth day expose the entire back for 5 minutes. Gradually increase the amount of exposure each day, but stay under dermatitis doses.

Young adults, for tonic purposes, use 8 minutes to 4 surfaces (two divisions of the front and back) the first day, and increase the time 5 minutes daily.

Babies 6 to 8 months old may start with ½ minute on the back and ½ minute on the front, and may increase the time of exposure 1 minute daily until 6 minutes are reached, front and back.

Heliotherapy should not be given if headaches, restlessness, elevation of the body temperature or of the pulse rate are present.

Ultraviolet transmitting windows are not at present practical except in special hospital solaria.

ARTIFICIAL ULTRAVIOLET THERAPY.—Carbon arc lamps consist of two carbon electrodes held in the lamp so that their free ends touch and are connected with a source of current. The current is started and the ends separate; the current continues to flow, striking an arc and producing an intense illumination. The radiation varies, depending on the carbon used, and the strength of the current. Radiation is emitted from the hot tips of the carbons and the arc itself. In general, mercury vapor lamps are more satisfactory.

QUARTZ MERCURY-VAPOR LAMPS are often designated as hot and cold.

Hot quartz lamps.—The principal part is the burner, a fused quartz tube, air-exhausted and containing mercury. The air-cooled lamps are mounted on a stand with a reflector and are used principally for general irradiation. In the water-cooled lamps the burner is surrounded by a water jacket with inflow and outflow pipes for cold water, and a window at one side for radiation after the heat has been absorbed. This type can be used in contact with the skin, and with suitable quartz rods, for an orificial application.

To operate, the water is started, the current is turned on, and the burner tilted slightly until the mercury runs across the vacuum and completes the circuit. The heat generated vaporizes enough mercury to fill the tube and the vapor conducts the current. Ten minutes should be used to build the tube up to maximum capacity of radiation.

All quartz burners deteriorate with age so erythema checks should be made frequently to determine the correct dosage.

Cold quartz lamps.—The radiating source is a fused quartz tube, highly evacuated, but containing rare gases (argon, xenon, and krypton) and a few drops of mercury. The tube is shaped in the form of a hexagonal grid for general irradiation and mounted on a large aluminum reflector. Alternating current is stepped up to 2,500 volts with low amperage (15–25) and a high voltage flow is provided in the tube. Emission takes place as a glow discharge. Full strength is obtained in about a minute, with 95 per cent radiation at 2,537 A. U. These lamps are proving very efficient.

Electrodeless high frequency induction lamps.—The radiating surface is a round bulb of quartz or corex—a glass which is evacuated and contains a tiny drop of mercury. The bulb is surrounded by a high frequency coil attached to a transformer of a diathermy machine. A current of 5,000 volts from the secondary brings the vapor of the mercury in the bulb to full luminescence in 30 seconds. The bulb remains cool, and does not deteriorate. Special applicators are made for all cavities of the body.

Tungsten filament bulbs of sun-lamp type.—A pyrex glass bulb filters ultraviolet rays shorter than 2,800 A. U. The bulb has a U-shaped tungsten filament and a small pool of mercury. Fifteen minutes application (average) gives a mild sunburn at 24 inches. A transformer is needed to operate these lamps in the usual house circuit.

TECHNIQUE OF GENERAL IRRADIATION.—The entire body is exposed and recumbent. Protect the eyes with dark goggles. Cover the genitals and face with a thin towel at first. In adults divide the front and back into 2 halves, giving 4 fields for treatment.

Dosage.—Each lamp must be calibrated for itself. A standard distance, as 30 inches, is best used. Cover forearm with paper with 3 dime-sized holes. Expose each for a different time, as 1, 3, and 5 minutes. In a few hours one should show a first erythema reaction which is the erythema reaction time of the lamp. Begin treatments at the standard distance, with tested erythema exposure time. Slowly change the time to 15 minutes, 2 minutes at a time (hot quartz lamp) then lower the lamp 2 inches at each successive treatment to 18 inches, 48 hours apart, but irritative doses are never applied except to small areas. No treatment should be repeated until reaction from the previous treatment has disappeared.

People of fair complexion, blondes, young children, and old people are more susceptible to the erythema-producing radiation than adults of the dark type. A safe routine is to give, for an initial dose, the aged one-half, women three-fourths, blondes and redheadheads one-third to one-fourth the average dose. The most sensitive areas in order are the face, chest, abdomen, back, sacral regions, arms, legs, hands, and feet.

LOCAL IRRADIATION.—The area to be treated must be cleaned of all grease, oils, etc., preferably by ether. For burns and clean granulating tissue give a mild erythema daily. For suppurating areas and old skin lesions use intensive dosage, as 4 minutes at 15 inches. From a new air-cooled mercury lamp this should produce a marked dermatitis (third-degree dermatitis). This treatment can be repeated every fourth or fifth day.

In erysipelas very intensive dosage, 20 times erythema has been given. For counterirritation in neuralgia, myositis, etc., give second and third degree erythema doses.

In applying ultraviolet therapy to mucous surfaces with quartz-rod applicators, about double the usual skin dosage may be used.

Clinical estimation of dosage.—Sub-erythemal—no visible reaction; first degree erythema (tonic dose) administered over entire body or large area, skin redden-

ing very slight, and disappears in 1 or 2 days with no trace; second degree erythema (stimulating dose) mild reaction, followed by slight desquamation that subsides in 3 days and may leave pigmentation; and third degree erythema (bactericidal dose or destructive dose) intense reddening after 2 hours, and blistering, persists for many days and leaves deep pigmentation.

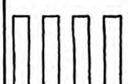
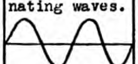
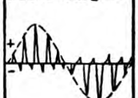
TYPE OF CURRENT	MODE OF FLOW	APPROXIMATE FREQUENCY	VOLTAGE	AMPERAGE	PHYSICAL EFFECTS AND USES	COMMON SOURCE
Galvanic.	Unidirectional; constant.		Low	Medium	Mild thermal. Chemical: (+) acid, hardens tissues; (-) alkaline, softens tissues. Both poles: Vasomotor stimulation. Promotes nutrition and relief of inflammatory conditions, and contusions. Ionic medication; surgical.	Motor generator as Morse.
Interrupted galvanic.	Unidirectional surge. 	Up to 100 per second.	Low	Medium	Mild thermal. Chemical: Alternating acid or alkaline. Dynamic: Motor and sensory stimulation. Muscle testing.	As above and break key.
Slow (Galvanic) sinusoidal.	Slow alternating waves. 	3 to 9 per minute.	Low	Medium	Stimulates smooth and skeletal muscle in flaccid paralysis.	Motor generators.
Interrupted or modulated alternating galvanic.	Rapid alternating waves. 	Up to 180 per second.	Low	Medium	Graduated contractions in non-paralyzed muscles.	Motor generators.
Faradic.	Rapid alternating asymmetric. 	80 to 100 per second.	Medium	Low	Electro-diagnosis.	Faradic coil, as Bristow coil.
Faradic surged.	Above surged. 	100 per second.	Medium	Low	Graduated exercise without tetany.	Motor driven device in above.
High frequency, (damped).	Extremely rapid alternating oscillations. 	1,000,000	High	High	Thermal: Increased circulation, sensory and motor sedation. Bactericidal. Relief of spasm and pain. Promotion of nitrition and absorption.	Conventional Diathermy.
High frequency, (undamped) Short and wave diathermy.	Extremely rapid alternating oscillations. 	Over 2,000,000 oscillations per second.	High	High	Profound thermal. Heating tissues. Hyperpyrexia. Cutting current.	High frequency, undamped apparatus.

FIGURE 180.—Currents used in electrotherapy.

Electrotherapy is the treatment of disease by means of electricity in the form of different kinds of electrical currents derived from various sources. Figure 180 shows the currents used in electrotherapy.

The **galvanic current** is a unidirectional and constant current of low voltage (2–100) and low amperage (1–50). It is obtained from wet or dry cells, from direct current mains with rheostat control, or from an alternating current supply changed to direct current by a motor generator or valve tubes. It is used: 1. To treat acute and chronic traumatic and inflammatory conditions, as contusions, spasms, or myositis; 2. For ionic medication in selected cases of arthritis, neuritis, neuralgia, and rheumatoid conditions; 3. As part of the follow-up treatment of selected cases of cerebral hæmorrhage; and 4. Surgically, in the treatment of benign new growths, superfluous hair, and dilated blood vessels.

TECHNIQUE.—The polarity of the galvanic current can be determined by dipping two metal electrodes from the apparatus in a bowl of salt solution. Bubbles arise from the negative pole.

The electrodes, metal plates covered with a well moistened pad (16 thicknesses of gauze) of the size and shape of the area to be treated, are applied firmly. If the electrodes are of equal size the polarity effect may be ignored, if unequal, the polarity effect will be more marked at the smaller electrode. Warm the skin first. Turn the apparatus on gradually, opening the rheostat until the desired current is obtained. If patient complains of burning, reduce the current, or turn the current off and remoisten and rearrange electrodes. Current within comfortable tolerance of patient, ½ to 1 milliampere of current per square inch of electrode surface. Treatments are usually given for 15 to 20 minutes, on alternate days, or started at 7 minutes and gradually increased to 40 minutes.

In cerebral applications the patient is recumbent, and two electrodes, 2 inches wide and 4 inches long, well secured at the forehead and nape of the neck, are used. The negative pole is at the forehead. The current must be constant, with no sudden changes, and started slowly at 1 milliampere and increased to 2 to 5 milliamperes daily or on alternate days. This treatment is used in post-hemiplegic conditions.

Galvanic baths are given in wooden or porcelain tubs, with two electrodes in wooden frames to prevent direct contact with patient. The current is turned on gradually to comfortable toleration, 500 to 200 milliamperes for 10 to 15 minutes. These baths cause general muscular stimulation, acceleration of metabolism, and are of value in generalized arthritic conditions, extensive paralysis, and neurasthenia.

IONIC MEDICATION.—A large dispersive electrode is applied to a convenient part of the body and the active electrode over a pad well moistened in the therapeutic solution is placed over the area to be treated. Current to comfortable tolerance is used for one-half hour. The following table gives information concerning substances used in ionic medication:

Drug	Active electrode	Use	Time
Sodium chloride, 1% solution	Negative pole.	Soften scars	½ hour daily or alternate days.
Iodine, 1% solution	do	Goiter; chronic synovitis	Do.
Salicylic acid, 1% solution	do	Resistant arthralgia	Do.
Quinine, 1% solution	Positive	Trigeminal neuralgia	Do.
Cocaine, 1% solution	do	Circular anæsthesia	Do.
Lithium ions, 1% solution	do	Gout	Few minutes.
Histamine (acid neoplate), 1 to 1,000 solutions.	do	Myositis; rheumatical condition, chronic.	Do.
Cholin, ½ to 1% solution	do	Periphera vascular processes	20–30 minutes.
Zinc chloride or zinc sulfate, ½% solution.	do	Indolent ulcers; chronic otitis media.	Comfortable (10) to toleration (30).

Interrupted galvanic current is produced by a mechanical device placed in a galvanic circuit that interrupts the current flow at regular intervals. This current causes muscular contraction beginning at the cathode on "make" and contraction beginning at the anode on "break" due to the chemical stimulation produced by the current. It is used for muscle testing and occasionally in cases of paralyzed muscles that will not respond to other currents. It also causes a sensation of pain at the sensory nerve endings in the skin.

Faradic current is produced by an induction or faradic coil. The intensity is regulated by varying the relation of the secondary and primary coils. This current produces a tetanic contraction of all muscles supplied by the motor nerve stimulated. It is seldom used except for electrodiagnosis because it is quite painful.

SURGING FARADIC CURRENT. A motor-driven device "surges" the faradic current by interposing varying resistances in its path and allows the use of this current for stimulating weak nonparalyzed muscles without painful tetanic contractions.

In the FARADIC VACUUM-TUBE CURRENT 120 short unidirectional impulses per second are produced by vacuum tubes; this current is nonpainful.

The **Slow (Galvanic) Sinusoidal Current** is a galvanic current passed through a rythmically varying resistance which at the same time periodically reverses the direction of flow of the current at the rate of 5 to 30 alternations per minute; it stimulates smooth and skeletal muscles in flaccid paralysis without painful contractions.

The **Surging** and **Interrupted Sinusoidal** or **Modulated Alternating Current** is a current with a more rapid alternation and surging, or rise and fall, than the slow sinusoidal, and which is well tolerated. It effects graduated contractions in nonparalyzed muscles. For simple muscle stimulation the patient should be comfortable and the muscles warmed and relaxed. Place a large dispersive electrode (3 by 4 inches) over the sternum or spine and a small active electrode 1 inch in diameter over the belly of the muscle. Moistened pads are used under the electrodes.

CLINICAL USES: In cases of *weak muscles with no organic nerve involvement* use the surged forms of faradic and interrupted modulated forms of alternating current with 50 to 100 alternations per second. The first stimulation should be weak, the second stronger, and the third still stronger. Rest, and repeat several times but avoid fatigue after treatment. Tremor in the muscle indicates too much current, or too long stimulation. Use voluntary exercise as soon as practicable. For *group stimulation* use the surged currents 5 to 10 minutes daily. Place the electrodes at the ends of the extremities, as at the sole of the foot, and under the buttock. Such currents are of especial value in disuse atrophy and are used for sprains, strains, contusions, hæmatoma, adhesions, myositis, torticollis, lumbago, atony of abdominal muscles after childbirth, and various joint adhesions. In the electrotherapy of *flaccid paralysis* the purpose is to retain some of the contractile power of the muscle until nerve function returns. The choice of currents is the slow (galvanic) sinusoidal. Place the dispersive electrode over the cervical or lumbar spine and the active electrode directly over the muscle. Great care must be used to avoid overfatigue of these very weak muscles. Start with 3 to 10 contractions, and only a flicker of motion at the tendon is necessary. Treat for 2 to 3 minutes, and gradually increase to 30 to 40 contractions for 15 minutes. Sometimes the interrupted galvanic current must be used to get a response. The treatment must be combined with muscle training, as is necessary after hemiplegia. For *spastic paralysis* use the surged or

interrupted alternating current only as an adjunct to muscle training and reeducation.

Electrodiagnosis deals with the reaction of muscles and motor nerves to electric stimuli and is a valuable aid in the diagnosis, prognosis and therapy of pathological conditions of the motor tract, including the brain, spinal cord, and peripheral nerves and, also, of the muscles.

In faradic testing, a faradic coil, activated by a galvanic (direct) current is used. The patient is placed comfortably in a well-lighted room. The muscles to be tested are warmed and relaxed. In unipolar testing place the large dispersive electrode any place where there is little muscle tissue, as over the sternum or sacrum. Using the faradic current set the active electrode over the motor point of the muscle or nerve to be tested, turn on the current with about 2 to 3 cm. on the secondary coil scale. Press the key of the interrupting handle and start the current flow. Change the coil until the lowest setting is obtained that gives a response. With the galvanic, use the negative pole for the active electrode and advance the rheostat slowly, pressing the key down from time to time to get the minimal response.

In testing with condensers use a technique similar to that used in galvanic testing. Various strength condensers are used consecutively for the test, and it gives an accurate measurement of the current needed. It is mainly used to indicate progress in infantile paralysis.

Reaction of Degeneration (abbreviated R. D.) indicates damage to the nerves, muscles, or both, and is shown when the response elicited is of a different type, and is elicited by a different current strength than under normal conditions. Standard texts must be consulted for full details of electrodiagnosis.

High frequency.—The essential source of high frequency currents is a supply of alternating current raised to a high voltage by electromagnetic induction (transformer). This high voltage current charges a set of condensers which discharge across a multiple spark gap. The spark discharge sets up oscillations of fairly well sustained damped (impeded) character at a rate of several hundred thousand to over a million a second. The high frequency current thus produced is conducted to the patient from the terminals of the apparatus by suitable electrodes and conductors.

Most high-frequency machines also contain an Oudin coil, which produces a very high-voltage current (Oudin current) which is led off a single terminal.

To operate a high-frequency apparatus turn on the main switch with the rheostat closed, allowing no current to flow to the transformer. Have spark gaps closed or slightly opened. Then open rheostat until the desired current is obtained. A pleasant treatment results when the rheostat is slowly opened and the spark gaps adjusted in balance. The milliammeter usually reads from 100 to 2,500 milliamperes, or if two are used, a high (1,000 to 4,000) and a low (100 to 1,000) is usual.

Diathermy apparatus of vacuum (thermionic) tube type is a more modern development of high-frequency apparatus and produces undamped oscillations of stable and efficient character through use of the three element or amplifier tube of DeForest.

Effects.—The rapid alternations do not produce sensory or motor effects as obtained with low frequencies. Heat is produced depending on the strength of the current, the resistance of the tissue, and the length of the treatment. Secondarily, an active arterial hyperæmia is produced, and metabolism is increased. Little permanent change in blood pressure results. A definite sedative effect is produced.

Clinical Uses.—High frequency currents are used for traumatic or inflammatory changes in joints, bursæ, and bones, chronic inflammation of intestinal organs, all chronic gonorrhœal infections, congestive lung conditions, neuritis, neuralgia and circulatory disorders.

Contraindications.—In general, any condition in which simpler heat is as effective. Specifically in acute inflammatory conditions with fever and suppuration, and also in conditions with tendency to hæmorrhage (as hæmoptysis).

Technique.—Block tin, gauge 22, is cut and molded to fit the part. If it is smooth and gives perfect contact, no soaping, etc., is necessary. Warm the skin slightly before applying. Bandage or sandbag to hold firm.

The *transverse* or *through and through method* is the common method. Two electrodes are placed on opposite sides of the part to be treated. If the electrodes are of equal size and the part thickness is not over 1½ times their greatest diameter there will be equal heating through the part. If the part is thicker, larger electrodes must be used. When unequal size electrodes are used, the smaller gets the most current and heat, and so can be used to heat a small superficial spot. In the *longitudinal* or *cuff method* two bent or cuff electrodes, placed fully or partly around an extremity, heat superficially. They must be 10–15 inches apart and the limb must be straight if the cuff goes completely around.

Dosage.—A comfortable sensation of heat only should be felt by the patient. This should occur when a current of 70 to 100 milliamperes per square inch of active electrode, if it is not a cuff or over 4 inches square, is used. About 1,200 to 1,500 milliamperes may be used for 4 by 6 inch electrodes.

Twenty minutes is the average time used for a treatment, on daily or alternate days, depending on the progress, although in some conditions a longer treatment may be advisable.

Safety Rules.—Electrodes must be in absolute skin contact to avoid burns. See that skin is unbroken and sensation normal. Instruct patient to report any uncomfortable sensation, as prickling or burning. Open main switch, open rheostat gradually, and then the spark gaps. Raise current slowly. Moderate heat is better over a longer period, than high heat over a short period.

Check all uncomfortable complaints of the patient.

Never leave a patient. Watch the milliammeter for an even flow of current. Stop treatment by turning switches in reverse order. Inspect electrode site. Cool patient before leaving department.

Monoterminal High Frequency.—The Oudin current is applied through glass vacuum or nonvacuum (condenser) electrodes.

In close contact for a long time it produces a mild heating. When the electrodes are moved with slight contact to give sparking, a mild counter irritation is produced. It is used in neuralgia of skin nerves; and in postoperative scar neuralgias (10 minutes, mild sparking). When applied for 15 minutes with fairly vigorous sparking, it acts as a counter irritant in deep seated pain. A mild sparking is used for sluggish ulcers, anal fissures, etc., and close contact for functional neuroses.

High-frequency Saturation is a modification of the monoterminal treatment. The patient holds in his hands a vacuum tube which is connected with the Oudin terminal. Diathermic massage can be performed while the patient is in contact with this current. A mild sedative effect is produced.

For General Diathermy large trunk electrodes are applied for 1 hour with a current of from 1,500 to 3,000 milliamperes. A temperature of about 100.6° F. and sweating is produced. It can be used on alternate days for a week in

general circulation disturbances, as mild arteriosclerosis, and general neuresthenic conditions.

In **Autocondensation** a current of 500 to 1,200 milliamperes is applied through a large body electrode, (a special chair or a large trunk electrode under a hair mattress) and a second electrode in direct body contact. Usually a metal bar is held in the hands. A mild heating effect and a general sedative effect is produced. It is most often used in hypertension.

Short-Wave Diathermy is the newest development of high-frequency currents in therapy. It is divided into two fields, *short-wave diathermy*, using 12 to 30 meter (M.) waves, (10,000,000 to 25,000,000 oscillations per second) and

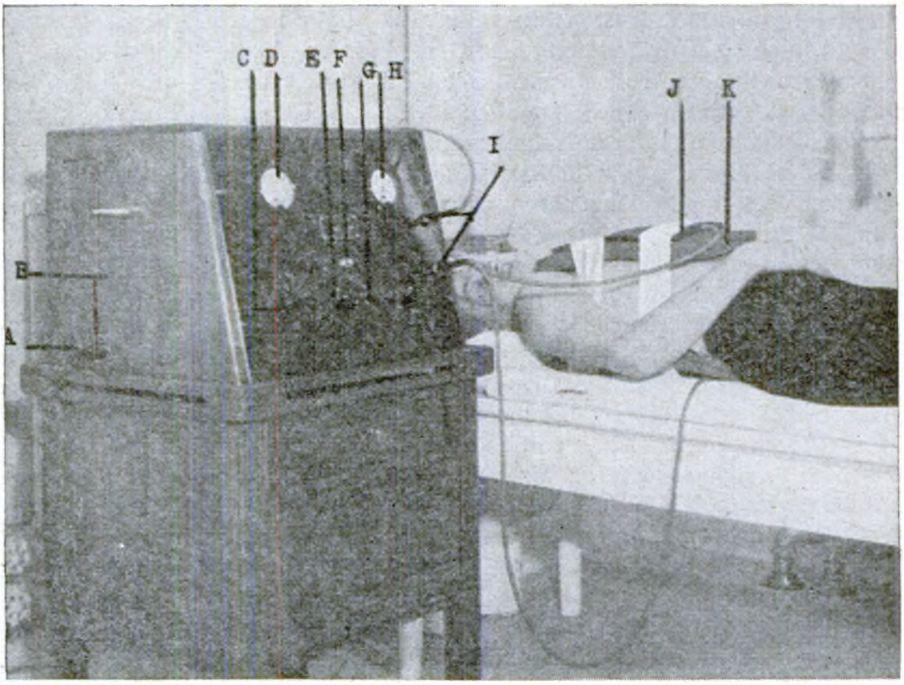


FIGURE 181.—Diathermy apparatus. A, foot switch plug, for use with surgical attachments; B, plug for electric current main; C, dial, power control; D, dial, milliammeter in power "input" circuit; E, plate switch, to be turned on after filament switch; F, filament switch; G, dial, resonance control; H, dial, milliammeter, in patient's circuit; I, jacks for electrode or surgical electrodes; J, electrode; K, sponge rubber to separate the electrode from the skin. Note that electrode cables do not touch the patient or each other.

ultra short-wave diathermy with waves below 12 M. (over 25,000,000 oscillations per second). It may be produced by vacuum tube oscillators, or by spark gap apparatus, but for practical reasons the tube apparatus is commonly used. An alternating current is passed through a stepup transformer to usually two rectifier tubes, and two oscillator tubes, combined with suitable inductance and capacity. Oscillations are transferred to the treatment circuit, and treatment plates attached to the ends of the circuit form condensers. A variable condenser or variable self induction is placed in the treatment circuit to bring the capacity of the patient into resonance with the main oscillating circuit. This is varied by the resonance control on the apparatus and when in resonance the highest output of the machine is obtained, and the highest reading is shown on the milliammeter. The oscillations are undamped. One type of apparatus is shown in figure 181.

The MODE OF HEATING differs from diathermy in that heating depends not on tissue resistance but on dielectric hysteresis, i. e. the heat generated by the friction of the rapid motion of the tiny particles comprising the body dielectrics in a very rapid oscillating condenser field. In the short wave field the therapy effect is the same, regardless of the wave length, and it can be applied to all conditions in which diathermy has been used, or in which heat is indicated. Selective effects have been claimed for ultra-short diathermy.

TECHNIQUE.—Condenser electrodes consist of flexible metal, covered with thick pliable rubber, with a suitable cable to connect with the jacks on the machine. They are made in various sizes, and special applicators are made for localized uses, as for sinuses and various body orifices. It is necessary that an air space be provided between the electrodes and the skin. Glass electrodes are made that incorporate definite skin (air) spacing in their construction, but for usual techniques rubber pads, felts, or folded towels are used. Four thicknesses of bath toweling gives a satisfactory spacing, and absorbs all perspiration from the skin. This is important in avoiding skin burns. The depth of heat effect is greatest with the greatest skin distance, and the heat effect is greatest on the skin when the electrodes are closest. The usual distance is 0.5 to 1.5 inches but for ultra short waves 2.0 inches is necessary. The electrodes or applicators should be of equal size, unless a heat point is desired, and spaced equidistant from the skin. If not, the closer pad concentrates the heat. Each applicator must be equidistant at all points from the skin to avoid "hot areas." This is very important over bony prominences, as the shoulder. With the electro-magnetic type of apparatus a coil is provided that is wrapped around a part, looped over it or coiled "pancake" over the area to be treated. The coils should be close together, and as near the skin as is comfortable.

In general, the size of the applicator depends on the area to be treated. for thick parts large electrodes well separated from the skin are used, to reduce the skin heat sensation and supply more energy. One may be used (unipolar) especially in treating conditions in which through and through heat is not wanted, as boils, the nasal sinuses, the middle ear, etc. (the other electrode must be connected to the machine). In general an electrode is placed on each side of the part to be treated, avoiding bony prominences as much as possible. They may both be placed on the same surface, but not too close together. The distance depends on the current used, and the size of the part, but not less than 6 inches. For pelvis heating, long narrow electrodes that encircle the body (36 by 6 inch "cuff electrodes") are used above and below the parts, or one in combination with a smaller "point heating" electrode. This may also be applied over the length of a limb. With large electrodes body temperature will be raised, so care to avoid chilling is necessary. The electrodes must be held in position with bandages or sandbags, but never put weight directly over a bony prominence. Place the electrodes, patient's *skin exposed*, turn on the filament current, the plate current, and adjust the resonance control to maximum reading, with power control (if one is provided) low. Wait for the sensation of heat by the patient; if too warm, turn back power and then resonance if necessary. If not warm enough increase power. *The one reliable guide to intensity of treatment is the patient's sense of heat.* Do not disregard complaints of too much heat, and instruct the patient carefully to report uncomfortable heat before beginning the treatment, for severe burns can occur. The milliammeter reading indicates a flow of current, but does not show the heat being applied, or generated in the tissues. This reading will change with any change in position of the electrodes, of the patient, or even because a person comes into the vicinity of the field. Care must be used in treating anæsthetic areas. A sense of com-

fortable heat is obtained and maintained. Pain in an extremity usually means too much heat, probably due to periosteal irritation.

In pneumonia short-wave diathermy is given by through and through electrode application over the affected side of the chest, or the electrodes may be placed parallel over the chest to avoid disturbing the patient. Forty-five to sixty minutes, once or twice daily.

Advantages.—Short-wave diathermy facilitates the treatment of regions to which it is hard or dangerous to apply diathermy, and permits use of simpler and more stable apparatus; plates are not applied directly to the skin; permits a simpler and more flexible technique; provides a more effective method of applying heat; and is safer than diathermy with comparable precautions.

Dangers.—Severe burns can be produced by overheating and improper electrode spacing.

Inductotherm.—A vacuum tube oscillator generating approximately 26 M. waves, is used to charge a cable which is applied around, about, or over a part to be treated. Heat is produced by electro-magnetic induction in the tissue, from the rapid oscillating cable current. Is an efficient source of diathermic heat, and is capable of producing hyperpyrexia.

Ultra Short-wave diathermy uses any wave length below 12 M., and 6 M. apparatus is in common use. Technique and indications are similar to short wave but greater spacing, 2 inches, must be used. It probably has no advantages over the longer waves in the short-wave field, and is more dangerous because the sensation of skin heat is not marked.

Hyperpyrexia (fever) can be easily induced in human subjects with high-frequency currents. This procedure however has definite dangers unless properly supervised, and should only be used in hospitals under direction of a medical officer familiar with this form of treatment.

A short-wave or inductothermy apparatus of suitable power, and insulating material are necessary. With short-wave diathermy, several insulating systems are used.

The Kettering Hypertherm, an air conditioned cabinet, heated with an electric unit and controlled by easily accessible humidistat and thermostat, is an efficient apparatus.

The patient (with weight bearing points greased) wrapped in toweling to absorb perspiration may be placed in a heavily insulated sleeping bag arrangement. Large electrodes are then placed over the body and the current applied. They should be moved frequently to avoid uncomfortable heat under them. The cable of the electro-magnetic machines, fixed in a disk and supported by a stand makes for easy application. This is also incorporated into a cabinet, and makes an efficient unit. The patient may also be effectively insulated by wrapping in toweling, a rubber sheet, and blankets. A temperature rise of 4 to 5 degrees F. is usually obtained the first hour, depending on the insulation, and the current is stopped about 1 degree F. short of the desired maximum. The current can be reapplied from time to time to maintain the desired temperature. In the treatment of resistant gonorrhœal conditions a temperature of 106 to 107 degrees F. is necessary for several hours. A frequently used treatment is a 10-hour period, and one such treatment is often sufficient for cure. The patient may need sedatives as sodium amytal or codeine, cramps or tetany may occur and require 10 cc of sodium gluconate intramuscularly. Tongue forceps, oxygen, and carbon-dioxide mixtures should be available for use if respiration becomes embarrassed. Intravenous dextrose, morphine sulfate, epinephrine chloride, and caffeine benzoate should also be prepared. Sodium chloride, 0.3 per cent, is given in water steadily. After the desired temperature is reached cool cloths

are used on the head. The temperature and pulse is taken every 15 minutes. Oral temperature is unreliable. After the treatment is completed, the patient is carried to bed, heavily wrapped in blankets, and the temperature is taken every ½ hour until normal. Fluids are continued.

Hyperpyrexia is most commonly used in gonorrhœa resistant to other treatment, nervous-system syphilis, cholera, and other neurological conditions.

Precautions with short-wave diathermy.—No metal parts in the treatment field (as hairpins). No metal or rubberoid materials on the treatment table. Cable must not touch the patient or chair, or the other cable. Do not treat through clothing, and inspect treatment area after each treatment. Do not use damp towels or felt for spacers. No not use pressure over bony points. Close points must be avoided in spacing. Treat anæsthetic areas with at least 2 inches skin distance. Do not give treatments "by the meter." Never disregard complaints of too much heat, and check applicators if unwanted point heating is complained of. Do not treat deep closed abscess cavities. Check spacing over protruding areas, as ears, etc. Do not touch electrodes with current on. Do not place electrodes on concrete, marble, or linoleum floors. Keep electrodes within 3 feet of each other. Avoid transcranial application when possible.

Electro-surgery denotes the application of electricity for the destruction of new growths and diseased tissue; and for cutting through normal tissue with minimal bleeding.

Electro-desiccation.—A needle point electrode connected to a single high voltage (Oudin) terminal is held in contact with or at a slight sparking distance from the area to be treated. It is a high voltage and low amperage current, the oscillations are damped, and result in drying and shrinking of the tissue due to water evaporation. A dry mass results which may be curretted or will slough off if left alone. **Fulguration** is the biterminal use of current from a high frequency coil. It is painful and has no advantage over desiccation.

Electro-coagulation.—This requires higher amperage and damped oscillations. A large dispersive electrode and a small active coagulative electrode is used. Although it is effective it is hard to regulate the size of the area coagulated.

Two small active electrodes as needles may be used and this limits the reaction to a small area between the needles.

Electro-section.—A needle point or thin blade is attached to one terminal of a high frequency apparatus current of undamped oscillations. This point cuts tissue readily with a minimum of coagulation, simply sealing the capillaries.

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Section 11.—RECRUITING

The strength of the Navy greatly depends on manpower and manpower is measured by the physical fitness of its personnel. This being so, it may be stated that the selection of the recruit is one of the most important functions of the Navy.

In order that enlistment may be possible to all, without the necessity of traveling long distances from their homes for the purpose of examination, recruiting stations are located in various large cities throughout the United States.

Generally the complement of a recruiting station consists of: The officer in charge of the station, usually a line officer who has been in the Navy a number of years; the medical officer, whose duty it is to examine carefully every applicant as to his physical and mental fitness and adaptability for the Navy; one or two yeomen for the regular office work; and a hospital corpsman to assist the medical officer.

The hospital corpsman is an integral part of the recruiting activity, and as a member of the medical department his duties are important. Especially is this the case where a pharmacist's mate is on duty at a substation or outlying station away from a medical officer. Here he must perform in a measure some of the functions of the medical officer in the preliminary examination of applicants and in eliminating those unfit for further examination. That means he must be capable and efficient, courteous and tactful, and well versed in the affairs incident to recruiting. It is well, therefore, to give an idea of the Organization of the Recruiting Service and its workings.

The Recruiting Section is a regular part of the Bureau of Navigation, constituted and operated like any other section of that bureau. From it come the orders and instructions governing all recruiting activities.

For convenience and efficiency, recruiting in the United States is separated into five divisions as follows: Northeastern; Southeastern; Southern; Central; and Western.

Under the above divisions there are about 35 Recruiting Districts and approximately 200 substations.

There are two Recruiting Training Schools, one at San Diego, Calif., and the other at Hampton Roads, Va., where special instruction and training are given to men prior to their assignment to duty at recruiting stations. It has been the policy whenever practicable to send pharmacist's mates to these schools for the course of instruction when assigned to recruiting duty. Members of the Hospital Corps to be eligible for such duty must be in good health, free of venereal diseases, and dentally sound.

The principle duties of the recruiting personnel are to secure suitable applicants and to enlist them in the Navy. A definite selective system is employed in securing applicants. This system aims to procure recruits of the highest quality. Such a method of recruiting raises the Navy standard; it also results in a smaller turnover in the personnel of the ships, in higher efficiency in ship operation, in reduction in desertions and discharges, and reduction in the cost of recruiting. Mistakes in recruiting resulting in rejection at the training station are expensive. It costs the Government about $650.00 to replace one man lost through avoidable means during the first year of enlistment.

The advantages which the Navy has to offer the applicant are:

1. A career;
2. Education (opportunity to learn a trade) and travel;
3. Physical improvement; and
4. A steady job with regular pay.

In return for these the Navy demands a full enlistment and a standard physical make-up. Here is where the medical department is chiefly concerned, which concern is the selection of applicants who measure up to the Navy standards for enlistment.

The chief duties of the medical officer are to review all applicants and give each a thorough and efficient physical examination to determine his physical qualifications. If the applicant cannot meet these requirements he is rejected.

The hospital corpsman is an assistant to the medical officer, and his duties are:

1. To assist in making contacts;
2. To assist the medical officer in physical examinations;
3. To help detect underlying defects in applicants;
4. To take care of recording and clerical work; and
5. To assist the medical officer in caring for station personnel.

The pharmacist's mate is an important cog in the recruiting machine and must fit in with the organization for its efficient operation. He should be selected with an eye to personality, education, and professional ability. Like the other members of the station he represents the Navy; he must look the part, be properly and neatly uniformed, and in all respects be prepared to uphold the high standards of the Navy in the community in which he is stationed. He must make the right impression upon the civilian population both in and out of the examining room.

Responsibility for accepting only those qualified physically for the service rests primarily with the medical personnel. This means a thorough investigation of the applicant's past history and his present status from standpoints of family and environment, together with a thorough physical examination.

There are two forms used at recruiting stations that are very useful in evaluating the physical requirements of the applicant. One is N. R. B. Form 10, which is the Recruiting Physical Examination Check-off List for use of nonmedical recruiters solely as a preliminary to the medical officer's examination. Use of this form enables recruiters to eliminate individuals who would not pass an examination before a medical officer. It does not take the place of the physical examination by the medical officer, and any applicant who is rejected by it may make a final appeal to the medical examiner at the recruiting station. No applicant is accepted or rejected solely on the findings of this check-off list. The other form referred to is N. R. B. Form 24. The first two pages of this form cover the application for enlistment; the third page is a record of the physical examination; and the final page is the applicant's physical questionnaire. This form gives a complete picture of the applicant as to his origin, home life and education, and physical make-up; and also a record of disabilities and abnormal conditions he may now have.

This physical questionnaire prepared by the recruiting station is forwarded to the training station in cases of all accepted applicants, for further reference. Every care should be used in making out this questionnaire, and it is the hospital corpsman's duty to see that the questions and answers by the applicant are thoroughly understood and the applicant is warned as to the seriousness of any false statement. Conditions such as bedwetting, fits, painful feet, and many others cannot be discovered unless the applicant is questioned definitely and pointedly on each defect named in the questionnaire. The easy way of just handing the applicant this blank form and allowing him to struggle over it himself defeats the purpose of the form.

Proper conduction of the physical investigation and examination will eliminate the unfit in most cases. It has been found that a large number of defectives were aware of their condition before enlistment. Painstaking and thorough examination of these at the time of interview would have eliminated most of them. The hospital corpsman, due to his close contact with the applicants, is in a position to materially aid the medical officer in discovering these underlying conditions. Failure to eliminate the unfit results annually

in discharges by medical survey, and by inaptitude and undesirable discharges. This means unnecessary expense to the Government.

During the examination refrain from an over-bearing attitude toward the applicant; a hospital corpsman must remember that the people he comes in contact with on recruiting duty are neither in the naval service nor are they his subordinates. Courtesy will reward his efforts, for the public will be impressed and formulate their opinion of not only the recruiting personnel but of the Navy as a whole by his general appearance and conduct.

Especially on recruiting duty one's private life must be strictly above reproach. Drunkenness, financial irresponsibility, marital troubles, or any scandalous conduct will not only reflect upon the individual but also upon the Navy as a whole. Many recruiting stations are in inland cities where few people know much about the general activities of the Navy and many questions will be asked, so it becomes an additional duty of a hospital corpsman to be able to intelligently give definite answers to many questions on Navy matters, such as advancement in ratings and pay, and the opportunities available for learning a trade.

Some of the more common physical causes of separation from the service are: 1. Bed wetting; 2. Epilepsy; 3. Flat feet; 4. Defective teeth; 5. Defective ears and hearing; 6. Defective vision; 7. Defective physical development; 8. Hernia; 9. Constitutional inferiority; and 10. Deformities.

Bed-wetting and epilepsy as well as constitutional inferiority are frequently covered up by the applicants. They are determined by careful investigation of the home and environment, school and social conduct.

Final acceptance is made at the main station after physical examination by the medical officer. The pharmacist's mate should be thoroughly familiar with the sections of the Manual of the Medical Department covering the physical examination of applicants for enlistment and should have at hand a list of causes for rejection. Physical defects should not be overlooked for they will be detected later at the training station and will result in the recruit's discharge from the service. Such errors reflect on the medical staff making the examination and lower the rating of the station, and incur useless expense to the Government.

It is necessary that careful consideration be given to the dental condition of all applicants for enlistment. The hospital corpsman is expected to be able not only to note the loss of a sufficient number of teeth to constitute a disqualifying defect, but also to detect gross pathological conditions of the teeth and their surrounding structures which would make the applicant for enlistment a poor physical risk. He should endeavor to acquaint the substation personnel with the dental requirements for enlistment and the causes for rejection.

Explanation of some of the dental standards or requirements which are often misconstrued follows.

1. An opposed tooth is one that comes into functional contact (hits or strikes) with one or more teeth of the opposite arch (jaw).
2. A vital tooth is a tooth containing a vital (not dead) dental pulp.
3. A serviceable tooth is one free from advanced disease, and that does not have a faulty restoration, crown or bridge attachment.
4. A permanent tooth is a natural tooth of the second dentition. Deciduous (temporary or baby) teeth are not counted as serviceable teeth.
5. An edentulous space is a space (gap) without natural teeth.
6. Malocclusion is a condition of malposition of the teeth resulting in abnormal occlusion (teeth do not mesh properly), or in a protrusion or retrusion (over or underbite) of either arch.

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Hospital corpsmen assigned to duty at recruiting stations should have adequate clerical ability in order to take care of recording and clerical work. A hospital corpsman often has to do this work in the main office with the yeomen, and his personality should be trained to fit in with that force. It may be desirable or necessary at times for each to assist the other in carrying out the clerical work. To illustrate the clerical work to be performed by a hospital corpsman, the following procedure is necessary for every recruit taken into the Navy:

1. Complete Form N. Nav. 2.
2. Complete pages 3 and 4 of service record.
3. Complete shipping articles, Form N. Nav. 351.
4. Complete application, Form N. R. B. 24 (previously mentioned).
5. Complete health record, N. M. S. Form H.
6. Complete N. M. S. Form "X" (Card).

Besides these the routine medical-department reports and returns have to be submitted as indicated.

Page 4 of the service record contains fingerprints. Especial care should be exercised in making fingerprints as they are a permanent record and at some future time may be a sole determining factor of identity. Smeared prints are useless and always must be remade.

There is another feature in connection with recruiting that comes back to rest with the Hospital Corps. Quite a number of hospital corpsmen are obtained from the ranks of the regular recruits. Recruits at the training stations are made familiar with the Hospital Corps and medical-department activities, and are given an opportunity to transfer to that organization whenever they so desire and are found to have the necessary educational qualifications. Many good men are taken from the ranks of apprentice seamen, sent through the Hospital Corps Schools and become hospital apprentices, second class. Watchfulness to this end will help much to secure recruits of the superior type which the Hospital Corps demands.

Section 12.—X-RAY

To become a competent X-ray technician requires special training. However, there are many small X-ray units that may be safely operated by carefully following the manufacturer's instructions provided the operator uses the proper safety precautions. Before attempting to operate even small units, it is a great advantage to know the principles of X-ray production and control. X-ray equipment is expensive and easily damaged, and when it is placed in ignorant hands, the danger to patients and operator can become very great. The information in the following pages will help operators to learn the reasons for the various controls and procedures. Further detailed instructions should be obtained, preferably by demonstrations, before attempting to use equipment.

HISTORICAL

X-rays were discovered by Whilhelm Konrad Rœntgen at the University of Wurzburg, Bavaria, in 1895. Many previous investigators had paved the way for his discovery. The colors produced in a vacuum tube by high voltage electric current had been observed by Geissler. Crookes had studied the effect of gradually increasing the vacuum until no current would pass through the tube. Other experimentors had discovered, during 35 years of research, that

certain crystals would give off light (fluoresce) when they were near such tubes in operation.

Rœntgen, however, made this important change in the usual experimental conditions—*he covered the tube with black paper so that no light was visible.* A neighboring cardboard, coated with barium platinocyanide crystals, gave off light as usual. But there was no visible light to activate the crystals. Furthermore Rœntgen was astounded when his hand accidentally came between the tube and screen and he saw the dim outlines of the bones. He reasoned that there must be some invisible rays coming through the black paper covering the tube. Rœntgen called these unknown rays "X-rays" and they have been known by this name ever since. They are also known as Rœntgen rays.

THE NATURE OF X-RAYS

X-rays are now considered as wave motions in the ether. The ether is the theoretical substance that fills all space. X-rays are similar in some respects to the rays of light emanating from the sun. There are several important differences: Visible sunlight can be broken up into its different colors (different wave lengths) or spectrum by a glass prism. Invisible X-rays, whose wave lengths are about 5,000 times shorter, can be broken up only, as far as is known, by certain crystals. They can neither be reflected from a mirror nor focused through a lens.

The most useful property of X-rays is their ability to penetrate solid objects. This they do in nearly direct proportion to the density of the object. Such materials as paper, cardboard, cotton, gauze, and wool are easily penetrated. Metals produce more obstruction. While a 1/16 inch thickness of a light metal such as aluminum can be readily penetrated, the same thickness of lead obstructs all but the short wave lengths.

There is a great difference in penetrating power of the short and long wave lengths. The shortest will penetrate over an inch of lead (million volt tube) while the longest will barely penetrate cardboard (Grenz rays).

For "seeing through" the human body, best results are obtained when the predominant wave length is just able to penetrate the denser parts. A beam of X-rays coming from a tube is composed of various wave lengths. By means of metal filters such as thin sheets of copper and aluminum the longer wave lengths are stopped (absorbed). The shorter ones go on through but still differ among themselves as to length and penetrating power.

The production of the shadow of an object by Rœntgen rays (X-rays) depends on: 1. The difference in density of the object and its surroundings; and 2. The penetrating power of the X-ray beam selected.

When the difference in density is great and a beam of proper penetrating power is used the contrast of the shadows on the film or screen is good. For example, the shadow of the dense heart will stand out very well because it is surrounded by the air filled lungs. The long bones are easy to demonstrate because they are surrounded by soft tissue of much less density. The organs of the abdomen are seen with difficulty because they and their surrounding structures are all of about the same density. Various methods have been devised to increase the density of certain organs. The stomach and colon are filled with barium mixtures. The kidneys and gall bladder are visualized by injecting certain dyes into the vein of the arm or taking them by mouth. The dyes are concentrated in the organ and increase its density so that it stands out from its surroundings.

It is highly important to remember that the object itself is never seen. What is seen is the shadow of the object. Just as hands and fingers may be ar-

ranged between a light and a white sheet to throw shadows resembling snakes, dogs, ducks, etc., so may the shadows on X-ray films and screens resemble things they are not.

PRODUCTION OF X-RAYS

To generate X-rays it is necessary that: 1. Electrons be separated from their atoms; and 2. Separated electrons be hurled with terrific velocity (⅓ to ½ the speed of light) against a suitable material.

The following is a simple explanation of X-ray production: "If a handful of marbles is thrown against a drum head, the marbles set up vibrations in the drum. These vibrations set up vibrations in the air that are recognized by the ear as sound. The marbles represent the electrons; the force that sets the marbles in motion represents the high voltage electric current that sets the electrons in motion; the drum head corresponds to the target of the X-ray tube; the sound waves produced in the drum correspond to the X-rays produced in the X-ray tube." The sound waves are long and travel through the air about 362 yards per second, while the X-ray waves are short and travel through the ether with the speed of light or 186,000 miles per second.

Electrons and atoms.—In the past atoms were thought of as the smallest particles of matter that could exist, which were joined together to form molecules. Today is it believed that atoms are composed of positive and negative charges of electricity which usually are exactly equal in number. The positive charges (protons) are considered as being contained in a central nucleus with part of the negative charges (electrons), the remaining negative charges revolving around the central nucleus in orbits like the earth revolves around the sun. (*See* chapter on Chemistry for a fuller discussion.)

When an atom has an equal number of protons and electrons it is a balanced atom, but this balance may be disturbed by several methods, a common one being the use of heat. When this occurs one or more electrons revolving in an orbit are lost and the atom is unbalanced. An atom may also become unbalanced by taking up electrons. When an atom loses electrons it has more positive than negative charges and is electrically positive as a whole. If an atom gains electrons it has more negative than positive charges and is electrically negative as a whole. If two such unbalanced atoms approach near enough to each other the excess electrons in one leave and take up the vacant places in the other and both atoms are again balanced.

When atoms are unbalanced there is a stress or tension between them due to the positive and negative charges seeking each other. This tension is spoken of as difference of potential or voltage. When the negative charges finally move toward the positive the resulting flow of electrons is called an electric current. This flow is always from negative to positive.

X-ray tubes.—A common type of X-ray tube, which is rapidly disappearing, is the Coolidge Universal Tube shown in figure 182. The tungsten anode (A) has a high melting point. This is important because about 99 per cent of the energy striking the anode is turned into heat. About 1 per cent is used to produce X-rays. The anode is the positive side of all X-ray tubes.

The cathode (C) or negative side of the tube contains a filament of tungsten wire similar to that of a small electric lamp. This is heated to white heat by the current in a small 12-volt circuit. The atoms of the filament are unbalanced by the heat which drives numerous electrons of negative charge to the surface. These negative electrons stay on the surface of the hot filament until high voltage current is applied to the positive and negative terminals of the tube. They are then attracted to the target which is positive. During

their travel of less than 1½ inches from filament to anode, these electrons attain enormous speed. They strike the target when their velocity is about one-half to one-third the speed of light. This tremendous speed sets the target into vibration causing it to give off wave motions in the ether known as X-rays.

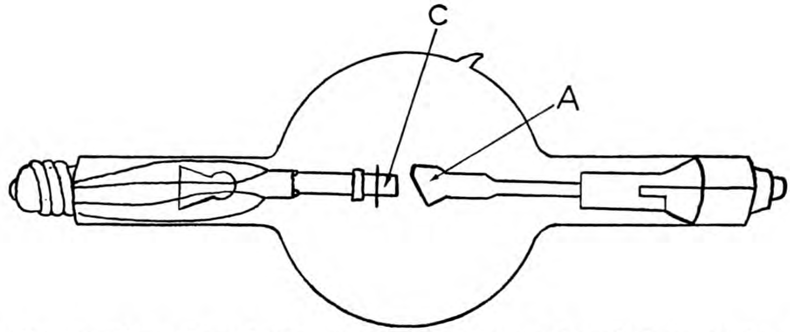

FIGURE 182.—Coolidge universal tube. A, anode and target; C, cathode containing filament.

All X-ray tubes are vacuum tubes. Producing a high vacuum is difficult and methods of attaining it are prized by manufacturers. Theoretically a perfect vacuum without electrons will not pass an electric current no matter how high the voltage. If the number of electrons released by the hot filament can be controlled, the amount of current that will pass through the tube can also be controlled. This, in turn, will control the quantity of X-rays produced. This is actually done by controlling the heat of the filament and is the big advantage of a hot filament X-ray tube. Prior to the perfection of this tube by Coolidge, electrons were badly controlled by adding and removing gas from a tube with a low vacuum. The gas tube is now rarely seen.

The radiator type Coolidge tube (figure 183) followed the universal type. The radiator (R), combined with a heavy copper anode (A), carried the heat away from the target much faster. This did away with "inverse" current when

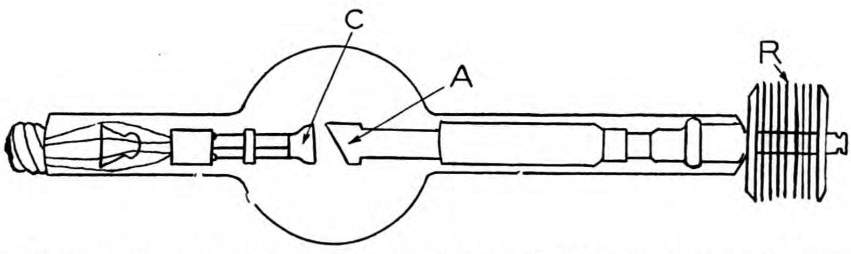

FIGURE 183.—Radiator type tube A, anode and target; C, cathode containing filament; R, radiator for cooling anode.

the tube was used without a rectifier (*see* figure 192). Then the glass bulb was made smaller and the radiator tube became a favorite for bedside machines and fluoroscopes on account of its small size and simple operation. However, its capacity of 10 to 30 milliamperes is too limited for high speed radiography.

To overcome these shortcomings, the heavy copper anode has been made heavier and the glass bulb larger. This allows even more rapid loss of heat. By adding a reservoir and circulating water around the anode, very rapid loss of heat has been attained. Tubes with 100 milliampere capacity and higher are now commonplace.

To obtain fine detail it is necessary to project X-rays from a small area on the target to film or screen. This is done by a focusing shield around the filament (figure 184). When electrons leave the filament, most of them are

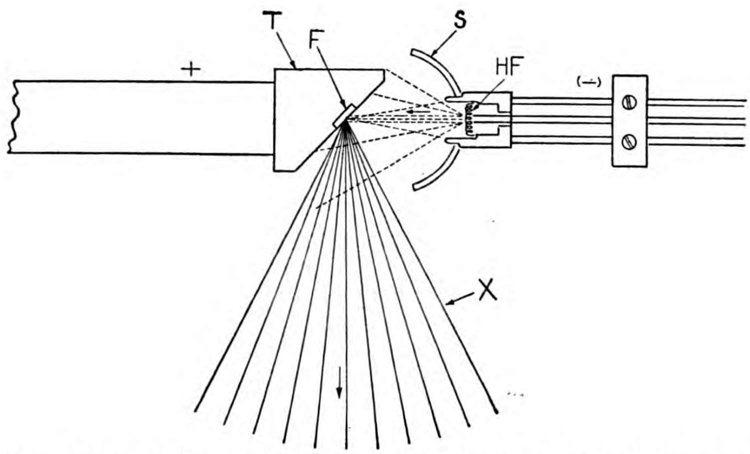

FIGURE 184.—Method of focusing electrons on the target. T, target; F, focal spot; S, focusing shield; HF, hot filament; X, X-ray beam.

focused on a small spot on the target. Tubes with focal spots less than 3 millimeters in diameter are called fine focus tubes. If the usual 45-degree slope of the target face is made smaller, it becomes possible to focus the cathode stream (or electrons) on a long, narrow line, instead of a small round spot, and the useful part of the X-ray beam is projected as a small square (figure 185). The great advantage of these "line focus" tubes is that the heat is distributed over a larger area on the target.

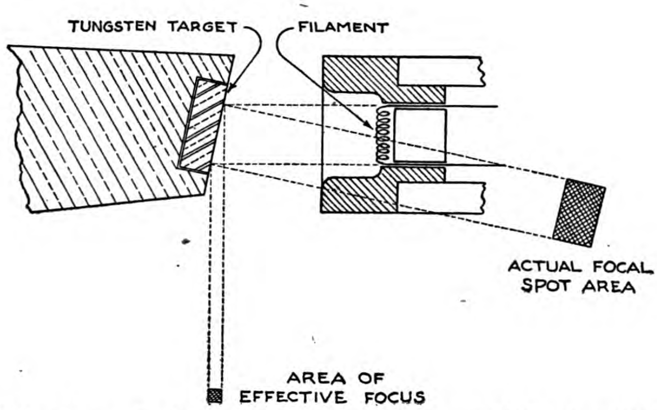

FIGURE 185.—Line focus, showing electrons focused on a much larger area than in Figure 184. Hence the metal is not raised to the melting point as quickly.

Figure 186 shows a line focus tube that is covered by a metal envelope (M). This is reinforced with lead near the anode. The latter prevents X-rays leaving the tube except through the opening directly under the line focus. The anode end takes either a radiator or a water reservoir. By using two filaments with a selective switch, one tube may serve for both fine and broad focus uses. These are called double focus tubes.

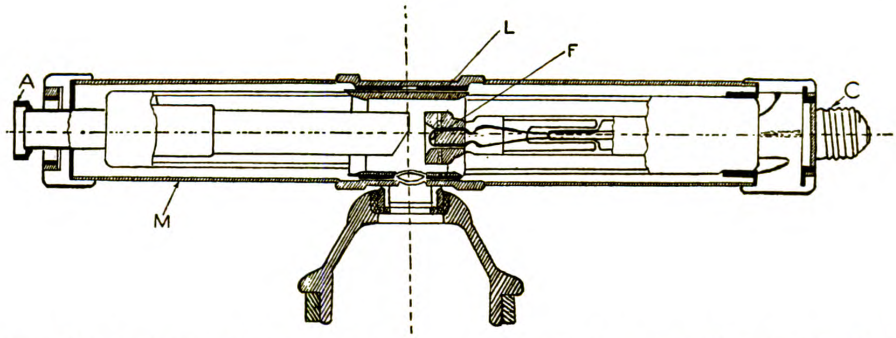

FIGURE 186.—Protected line focus tube. A, anode terminal; C, cathode terminal; F, filament; L, lead lining above and below target with X-ray window; M, metal envelope.

Figure 187 shows a rotating anode tube. The disc-shaped anode is rotated by a small motor. Heat is distributed over the whole circumference of the disc. This tube will do the heavy work of a broad focus tube with the fine radiographic detail of a fine focus tube.

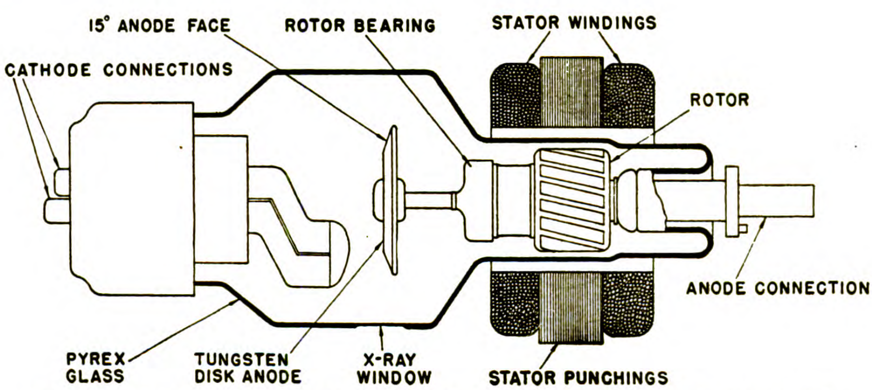

FIGURE 187.—Rotating anode tube. (General Electric X-ray Corporation.)

Various types of tubes are used for treatment. Some of these are very large, require upwards of one million volts to operate, and must be installed in specially constructed buildings.

SECONDARY HIGH VOLTAGE CURRENT

The separation of electrons from their atoms and how they are stopped abruptly by the target of the X-ray tube has been explained. The force that hurls these electrons with terrific velocity against the target is the high voltage electric current coming from the secondary coil of the X-ray step-up transformer (figure 188).

A modern X-ray transformer consists of a square or ring of iron (closed core) with two separate coils of wire. One coil is called the primary, the other the secondary. They are insulated from each other by the surrounding coil. The secondary coil has many more turns and is made of smaller wire than the primary. Low voltages are sent through the primary coil. This causes the whole iron ring to become a magnet. The magnet induces a high voltage current in the secondary coil. This induced current will have a voltage in direct proportion (ignoring losses) as the number of turns in the primary coil is

to the number of turns in the secondary coil. For example, suppose there are 22 turns of wire in the primary coil with a voltage of 220. If there are 8,800 turns of wire in the secondary coil then there are 400 times as many turns as there are in the primary, hence, the voltage in the secondary coil is $400 \times 220 = 88{,}000$ volts.

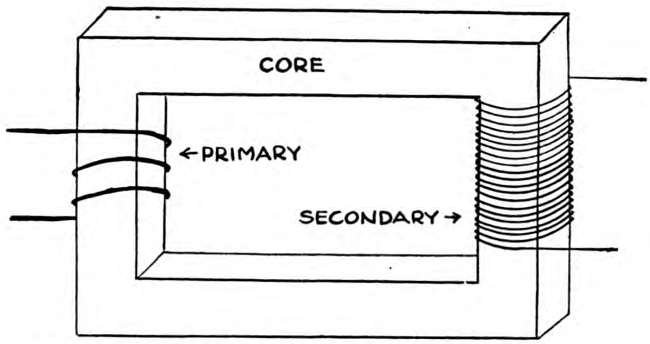

FIGURE 188.—Diagram of X-ray transformer wiring.

Induction.

The 88,000-volt current just mentioned is an induced current. Electric current can be created or induced in a coil of wire by pushing a magnet within the coil (figure 189). Also, a magnet can be treated or induced by placing a bar of soft iron in a coil of wire carrying an electric current.

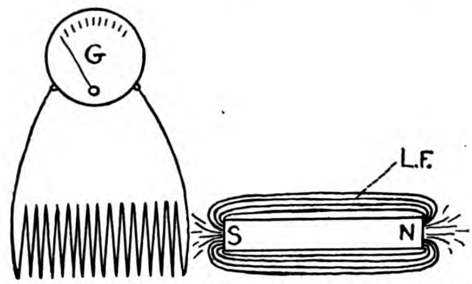

FIGURE 189.—Induction. When a magnet, NS, is pushed into a coil of wire, lines of magnetic force, LF, are cut, causing an electric current to flow in the wire and register on the galvanometer, G. (After Sante.)

In the X-ray transformer the ring of iron is turned into a magnet when electric current is passed through the primary coil. This magnet has a field of magnetic influence surrounding it, which is similar to the field shown in figure 189. It is convenient to picture this field as "lines of magnetic force." When lines of magnetic force are being cut by a wire passing through them, an electric current flows in the wire. When the motion stops the current stops. Increasing the number of turns of wire around the magnet increases the number of lines of force that are cut which increases the amount of current produced. If the lines of force can be moved across the wire it amounts to the same thing as moving the wire across the lines of force. These lines are rapidly moved by the alternating current flowing in the primary coil. If direct current is used, it must be changed to alternating current before it reaches the transformer. This is accomplished by a rotary converter.

When speaking of volts the pressure of an electric current is meant; when speaking of amperes the rate of flow is meant. A high pressure can be pro-

duced in a small water pipe by a pump while the volume of water flowing will be small. A high voltage can be produced in a small sized wire by a step-up transformer, yet the amount of electrical current flowing (amperage) will be small. This is a suitable type of electrical current for the production of X-rays.

The voltages used for production of X-rays usually vary from 30,000 to 200,000. These are awkward figures and the custom has developed of measuring in "kilovolts". One kilovolt equals 1,000 volts; 80 kilovolts equals 80,000 volts, etc. These high voltages are measured by observing the distance they will cause a spark to jump through air. The point gaps or sphere gaps are gradually closed by moving the points or spheres toward each other until a spark jumps across. The scale of point gaps reads in inches. Six inches equals about 100 kilovolts. The scale of sphere gaps reads directly in kilovolts.

The amperages used for production of X-rays vary from 0.004 to 0.500 of an ampere. These figures are awkward, so amperage is measured in "miliamperes". One milliampere equals 0.001 of an ampere; 50 milliamperes equals 0.050 of an ampere, etc. Milliamperes are measured by a special type of ampere meter called a milliammeter, which is connected in the high voltage secondary circuit. On small units a low voltage meter is mounted on the control stand. This meter is calibrated in milliamperes at the factory by comparing it with a standard milliammeter.

Rectification.

When the high voltage current leaves the secondary coil of the transformer it is alternating current. Like the current introduced into the primary coil, it rises from zero to its peak and falls back to zero again (figure 190). Then the

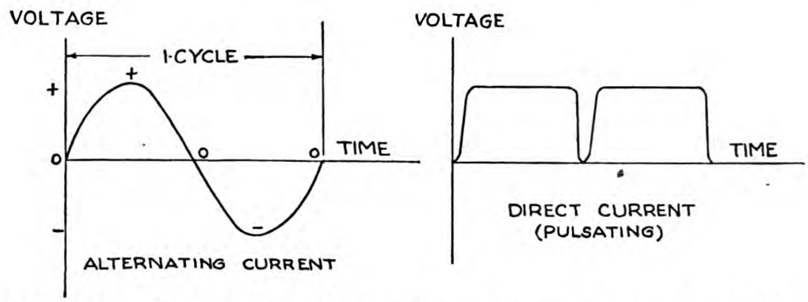

FIGURE 190.—Wave forms of low voltage primary alternating current and high voltage secondary full wave rectified current. The form of the latter, which is direct pulsating current, has been modified by condensers.

current reverses its direction and falls below zero an equal amount to return again to zero. These events are called a cycle. Most electric power supplied today is 60 cycle alternating current. That means that 60 such cycles occur every second or 3,600 cycles occur every minute. Each cycle has two impulses which flow in opposite directions.

To produce X-rays it is necessary that current flow through the X-ray tube in one direction only. It must flow to the cathode where it is picked up by "small boats" (electrons) and carried to the anode. The current must always leave the anode and return to the transformer in order to complete the circuit.

One way of doing this is to select only that part of the alternating current that is flowing in the right direction. In other words, only half of each cycle is used. This is called half-wave rectification. If the target of an X-ray tube

can be kept cool enough so that electrons will not be released from it, the tube itself will make this selection (self-rectification).

With electrons available only at the hot filament (cathode) the current must approach from the cathode side to find transportation. When the current tries to cross from anode to cathode, no electrons are available.

This is satisfactory for a small number of watts (volts × amperes = watts), but when more watts are used the target heats, electrons are released and "inverse" current passes from anode to cathode. Hence, when more X-rays or more penetrating X-rays are wanted, it becomes necessary to rectify the current before it reaches the X-ray tube.

Many ingenious methods of rectification have been devised. Figure 191 shows a mechanical rectifying switch in the shape of a disc. The disc is made of insulating material that carries copper contacts. It is turned by a synchronous motor that makes one-half of a complete revolution on each cycle

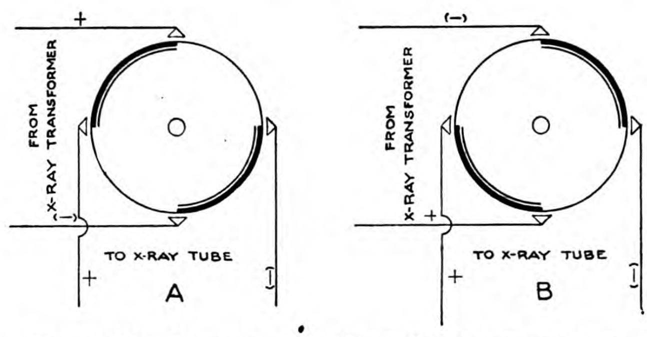

FIGURE 191.—Diagram of rectifying disc in two positions.

of the alternating current. As there are 30 revolutions of the disc per second and 60 cycles of alternating current per second, the disc can be adjusted on the shaft so that the contacts reach the terminals connected to the transformer at just the right moment. Thus, the current entering the switch is changing its direction 120 times per second while the current leaving the switch has 120 impulses per second but all in the same direction.

Figure 192 is a valve-tube rectifier. Modern valve tubes have a cylindrical metal plate (A. A.) surrounding a spiral filament. The filament is heated by a current of 12 to 14 amperes passing through the terminals (F. F.). The hot filament releases electrons which carry the current across the vacuum to the plate. This tube will pass current only in the direction of the large arrow.

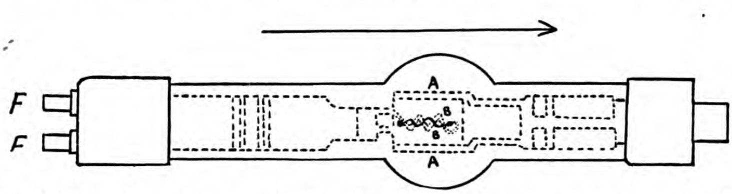

FIGURE 192.—Valve tube. A. A., cylindrical metal plate surrounding a spiral filament; F. F., filament terminals. (Sante.)

Figure 193 is a two-valve, half-wave rectifier. When the current from the X-ray transformer is flowing to the left it meets the heated filament of valve tube (A) where plenty of electrons are waiting to carry it across the vacuum to the plate. The current crosses the X-ray tube and valve tube (B) in similar fashion and completes the circuit by arriving at the opposite end of the trans-

former secondary. When the current is flowing to the right, it meets the plate of valve tube (B). No electrons are waiting to carry it across and hence no current passes. Notice that only half of each alternating cycle is used and that the X-ray tube receives 60 impulses per second.

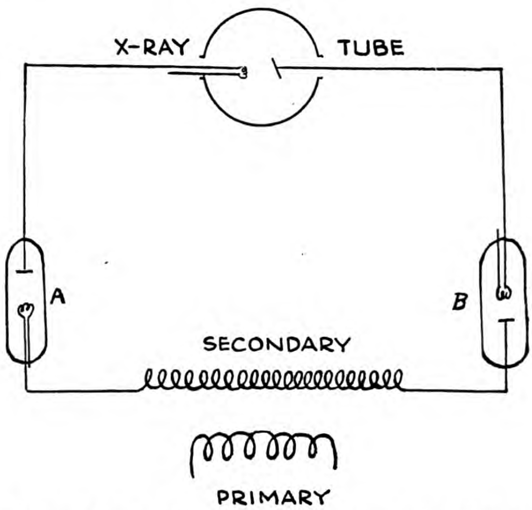

FIGURE 193.—Circuit diagram of two-valve half-wave rectifier.

Figure 194 is a four-valve full-wave rectifier. When the current from the X-ray transformer is flowing upward it passes through valve tube (A), to X-ray tube, to valve tube (B) and completes the circuit by arriving at the lower end of the transformer secondary. When the current is flowing downward it passes through valve tube (C) to X-ray tube to valve tube (D) and completes

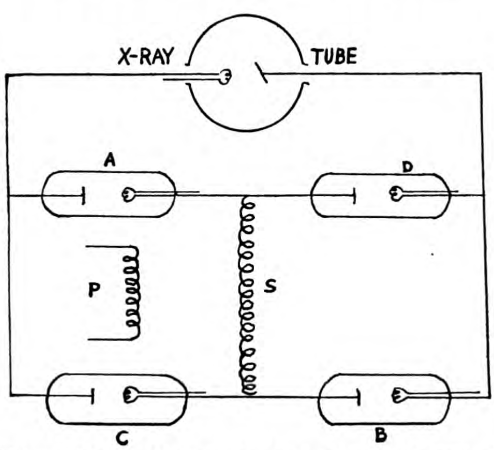

FIGURE 194.—Circuit diagram of four-valve full-wave rectifier.

the circuit by arriving at the upper end of the transformer. With 60-cycle alternating current the X-ray tube passes 120 impulses per second. Each valve tube passes 60 impulses and stops 60 impulses per second. Notice that the whole alternating cycle is used. The direct pulsating curve shown in figure 190 is similar to full-wave rectified current combined with condensers. Full-wave rectification wears out the X-ray tube faster than other types because there are no cooling intervals. However, it is very efficient for fast exposures.

Figure 195 shows the essential parts of the secondary circuit connected together. The rectifier is a revolving disc type. Other types of rectifiers can be substituted.

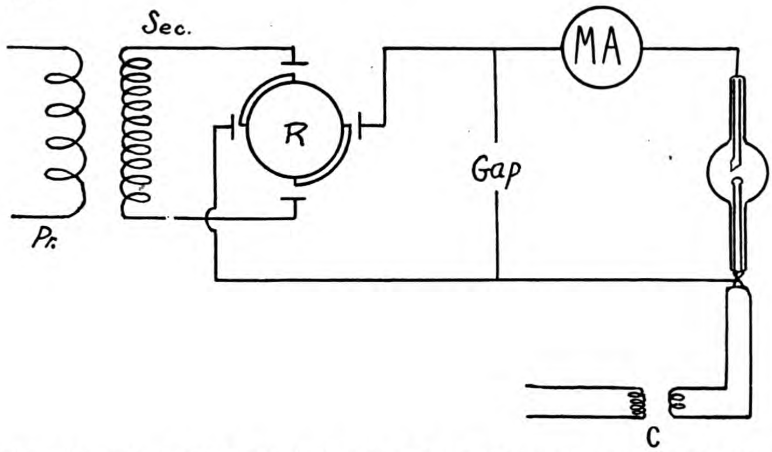

FIGURE 195.—Diagram of the principal parts of the high voltage secondary circuit and filament circuit connected to X-ray tube. Sec., secondary coil of X-ray transformer; R, rectifier; MA, milliampere meter; C, step-down transformer of filament circuit.

PRIMARY LOW VOLTAGE CURRENT

Before the current enters the primary coil of the step-up transformer, it must pass through several devices. Some of these serve to control the input. Others serve to automatically shut off the current in case of grounding or short circuit.

Fuses.

If one starts at the power panel switch or lamp socket to which the X-ray machine is connected, the first devices usually met are the fuses. These are similar to the fuses of a lighting circuit in a private home. A small bedside machine will be equipped with 10- or 15-ampere fuses. A large X-ray machine may carry 200-ampere fuses or larger.

Such fuses consist of a short piece of flat wire inside a cartridge with contacts on each end, or they may be the type that screw into a socket. A fuse wire designed to pass 200 amperes of current at 220 volts should melt if more than 200 amperes is "drawn" by the X-ray machine. Most X-ray machines never use this amount of current unless something goes wrong. This something is usually a "grounded" circuit and may be on either the primary or secondary side. Because the secondary circuit is high tension, which is constantly seeking escape, most "grounds" occur there. This makes it easy for current to flow because the resistance of the X-ray tube has been avoided. The situation is similar to a bursted water main. Great quantities of current are demanded from the transformer. The voltage (pressure) drops and the rate of flow (amperes) increases. Unless something is done immediately, the heat generated by the heavy current will "burn out" the transformer, or, worse still, if a patient's or operator's body is responsible for the ground, this heavy current is passing through him and may result in death.

While fuses can usually be depended upon to protect the transformer from "grounds", they are not always dependable for protection of personnel. A person may "ground" the high-tension current sufficiently to kill himself and yet not make good enough ground contact to pass a heavy current that will melt the fuses. The best method is to use fuses whose capacity is just above the routine operating requirements of the X-ray machine.

On leaving the fuses, the current usually meets another safety device called a **circuit breaker.** A simple type (figure 196) is composed of a coil of wire surrounding a bar of iron (I). The coil is connected in the primary circuit.

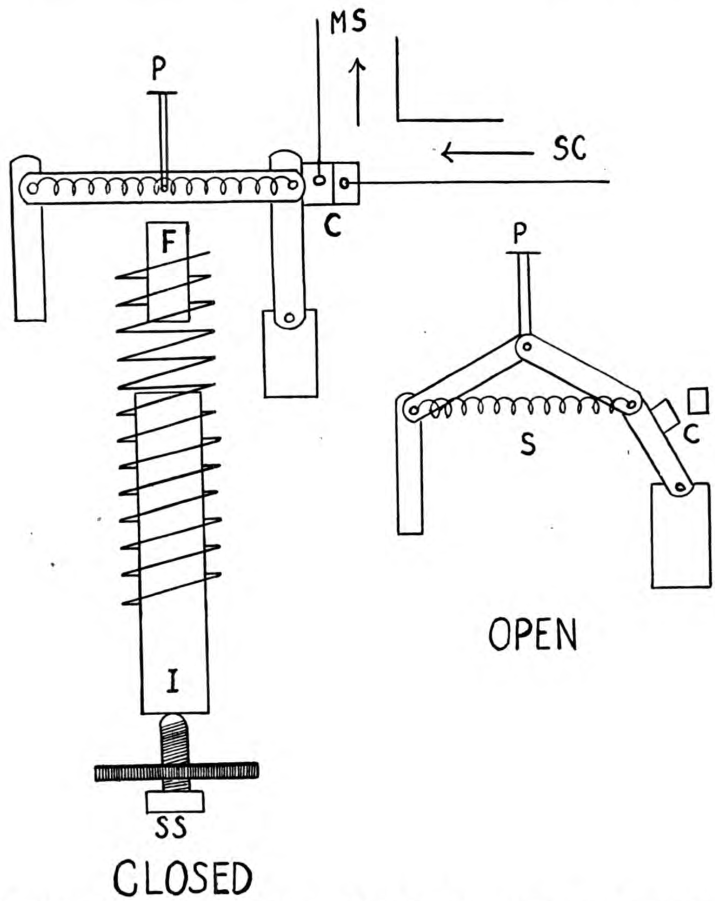

FIGURE 196.—Diagram of circuit breaker. When the primary current increases beyond the limit set, the iron bar, I, is drawn farther into the coil of wire and strikes the fiber plunger, F, which trips the spring device, S; C, contact; SC, incoming special circuit; MS, outgoing circuit to magnetic switch; P, handle for setting breaker; SS, set screw.

Whenever an unusual amount of current starts to flow, the iron bar is drawn, by magnetic force, farther into the coil. Here the bar meets a plunger (F) which trips a spring device (S). This opens the contact (C) and the primary circuit is broken by a magnetic switch. The circuit breaker may be made more sensitive by pushing the iron bar farther into the coil by means of the set screw (SS).

After the primary current has passed through the fuses, circuit breaker, and a line switch, it meets the **autotransformer** (**AT** in figure 197). This is a device which steps down the voltage by induction. It consists of a single coil of heavy wire wound around an iron bar (B). The same coil of wire serves as both primary and secondary.

It is a proven fact that two electrical currents may travel over the same wire without interfering with each other. Telephone wires often carry several different circuits at the same time. When alternating current flows through the coil of the autotransformer it produces lines of force about the iron bar. These

lines of force are cut by the same coil of wire that produced them. If the taps from the coil are removed a current of the same voltage as the primary will be induced in the same coil. This induced current always works against the primary current. As the voltage of the primary alternating current is falling the voltage of the induced current is rising. The net result is zero as far as flow (amperage) of current is concerned. Such a device is known as a choke coil. The induced voltage is called counter electromotive force.

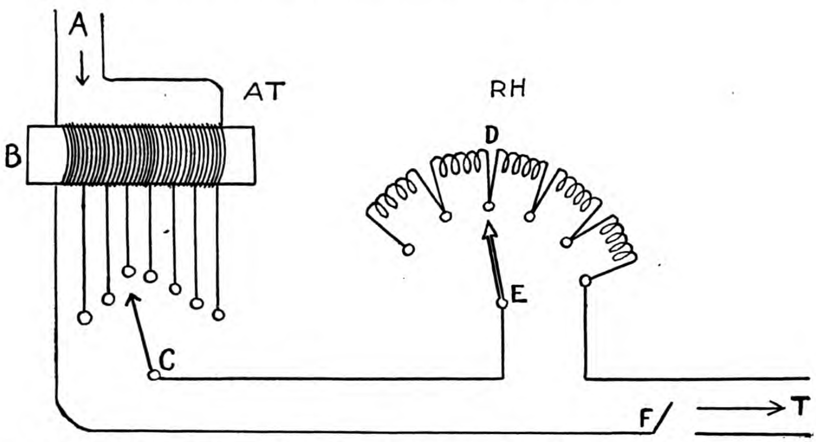

FIGURE 197.—Diagram of the principal control devices in the primary circuit. A, incoming alternating current; AT, autotransformer with iron bar, B, and contact arm, C; RH, rheostat with resistance coils, D, and contact arm, E; F, X-ray switch; T, outgoing alternating current to X-ray transformer.

Adding the taps or leads to several coils, and connecting any two of them to a current consuming circuit, makes an autotransformer out of a choke coil. The induced voltage now has an outlet. Not all of it is expended in "bucking" the primary voltage. This also allows primary current (amperage) to flow because there is less force against it. In practice, both the primary and induced low voltages are referred to as the primary circuit of the X-ray transformer.

When the contract arm (C) is on the button as shown in figure 197, there are 15 turns of wire in the outgoing circuit.

As there are 35 turns in the whole coil the incoming voltage is to the outgoing voltage as 35 is to 15. In other words, the outgoing voltage is three-sevenths of the incoming. Thus, if the incoming voltage is 110, the outgoing voltage, ignoring losses, will be 3/7 of 110 or 47 volts. Modern autotransformers have many more turns of wire and many more taps so that steps of 2 volts may be obtained. It is bad practice to change the setting of an autotransformer when it is passing current because of arcing between contact points.

The reading of the **voltmeter** is controlled by the autotransformer. Thus the proper incoming voltage for the work in hand may be selected. The voltmeter is sometimes calibrated in kilovolts at the factory where spark gap readings are taken simultaneously with voltmeter readings. The line voltage must agree with the factory voltage for the scale to read correctly. This is adjusted by a compensator which is a small autotransformer and voltmeter connected ahead of the autotransformer. When a compensator is used, the main autotransformer steps may be calibrated in kilovolts and the second voltmeter omitted.

On leaving the voltmeter, the primary current usually meets a **resistance**. In some controls this resistance is permanent and the operator frequently is unaware of its presence. In controls for larger machines, this resistance is variable and is known as a rheostat (RH in figure 197). A resistance is a coil of wire or

series of grids that checks the flow of electricity because the arrangement of their atoms is unfavorable. The metal used in rheostats has a high resistance and is a poor conductor.

The unit of resistance is called the ohm. A resistance of one ohm will pass one ampere of current at a pressure of one volt. A resistance of 5 ohms will pass 1 ampere of current at a pressure of 5 volts, 2 amperes at 10 volts, and 20 amperes at 100 volts. The current used up by the resistance is converted into heat. This is accompanied by a drop in voltage.

The rheostat in figure 197 has five coils and a contact button for each coil. Suppose that each coil has a resistance of one ohm. If the contact arm is placed on the button to the extreme left, all five coils are in the circuit. With the autotransformer set to feed 47 volts to the rheostat, the largest amount of current that will pass is a little over 9 amperes. If the voltage should drop to 40 the largest amount of current that will pass is 8 amperes. If the resistance of the X-ray tube is avoided by the current taking an easier path (short circuit or ground), these examples do not hold because the total resistance of the combined primary and secondary circuits has been reduced.

Compare the autotransformer to the rheostat. When the supply line voltage entering the autotransformer drops from 110 to 100, the voltage leaving the autotransformer drops from 47 (when set for this voltage) to about 43 volts. However, the amperage does not drop. Thus, the important difference between autotransformer and rheostat control is the loss of voltage and current with the latter. When the two methods of control are combined as in figure 197, the rheostat is "cut out" for film exposures (radiography). When giving treatments (therapy) some variable resistance is usually left in so that settings may be changed to compensate for line fluctuations.

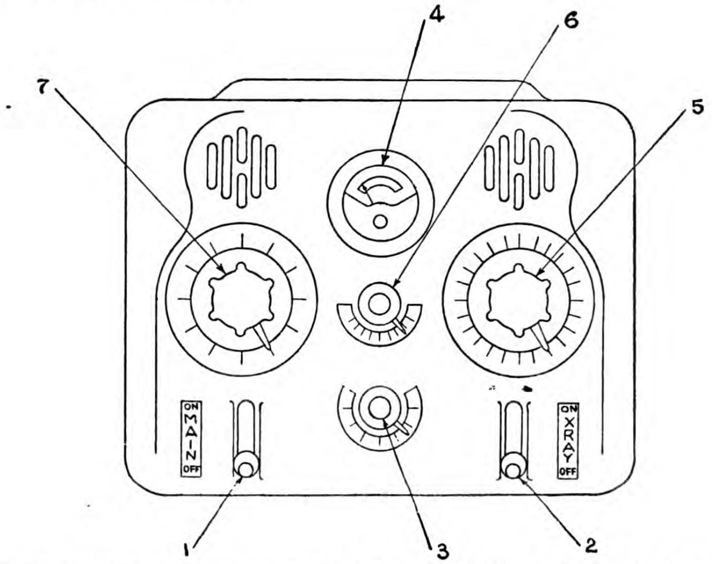

FIGURE 198.—Operating devices on control stand. 1, line switch; 2, X-ray switch; 3, voltage compensator; 4, voltmeter; 5, autotransformer control; 6, resistance; 7, filament regulator. (General Electric X-ray Corporation design.)

X-ray switch.—When the current leaves the resistance it has passed through the various controls and safety devices of the primary circuit and is ready for the primary coil of the X-ray transformer. It is convenient to have a switch at this point that may be opened and closed for short or long intervals (F in figure 197). The time of the X-ray exposure on a film or fluoroscopic screen and the

treatment of a patient is controlled by closing this switch for the proper interval. The X-ray switch is placed on the control stand (figure 198). Frequently there is a timing device and a foot switch connected with it. The latter are merely convenient forms of X-ray switches, all of which send the current to the primary coil of the X-ray step-up transformer.

ARRANGEMENT OF X-RAY EQUIPMENT

The foregoing discussion started with the production of X-rays and worked backward in the high voltage secondary circuit to the secondary coil of the step-up transformer. Then it started again at the supply line of the ship or building and worked forward in the low voltage primary circuit to the primary coil of the step-up transformer (figure 188). These two divisions, high voltage and low voltage are arranged in a very different manner.

Practically all of the low voltage control and safety devices of the primary circuit are found in the control stand (figure 198). This includes fuses, circuit breaker, line switch, autotransformer, voltmeter, rheostat, and the X-ray switch with its accessory-timer and foot switch connections. The control stand also carries an ammeter and a choke coil or resistance control to regulate the amount of current flowing to the step-down transformer of the filament circuit. The meter may be connected in the overhead system. These regulate the heat of the filament in the X-ray tube. It will be recalled that the heat of the filament regulates the amount of current (milliamperes) that pass across the X-ray tube. This, in turn, regulates the amount of current drawn from the step-up transformer and power line.

The low voltage current leaves the control stand at a pressure of 40 to 210 volts and enters the step-up transformer. It leaves the step-up transformer at a pressure of 30 to 200 kilovolts or higher. A pressure of 100 kilovolts will cause a spark to jump across a 6-inch air gap. If this current is not kept confined to its proper channels it becomes very dangerous. This is accompanied by locating the high voltage lines high enough to be out of reach. The connecting wires brought down from the overhead system to the X-ray tube are wound on reels containing a spring. The reels exert a constant pull and keep the wires away from the table and patient. These precautions have never been "fool proof" and many fatal contacts with high-tension wires are on record.

SHOCK PROOF EQUIPMENT

Two recent designs of X-ray apparatus have practically eliminated the danger of electric shock. The safest design is that shown in figure 199. All of the high-tension secondary circuit, including the step-up transformer and X-ray tube is mounted on insulators and enclosed in a grounded metal casting. This hollow metal casting or "head" is filled with oil having a high resistance. Starting with small self-rectifying dental X-ray tubes, this design has been developed at present writing to enclose valve tubes, filament transformer, therapy tube, and step-up transformer of 400 kilovolt capacity.

Another design encloses only the X-ray tube in oil. This is combined with heavily insulated cables connecting the tube to the overhead system (figure 200). Thus, the most dangerous high tension parts are protected.

X-RAY EXAMINATIONS

There are two methods of examining with X-ray equipment, the screen and the film. Screen examinations should always be made by persons having extensive knowledge of anatomy, physiology, and pathology. Otherwise, they lose

most of their value and may lead to wrong conclusions. The film method requires similar knowledge for interpretation of the shadows. It will be recalled that these shadows often resemble things they are not. However, the exposure of the film and its processing in the dark room do not require medical training for satisfactory results. This technical part of Rœntgenology, as the science of X-ray is called, is rightfully placed in the hands of X-ray technicians under medical direction.

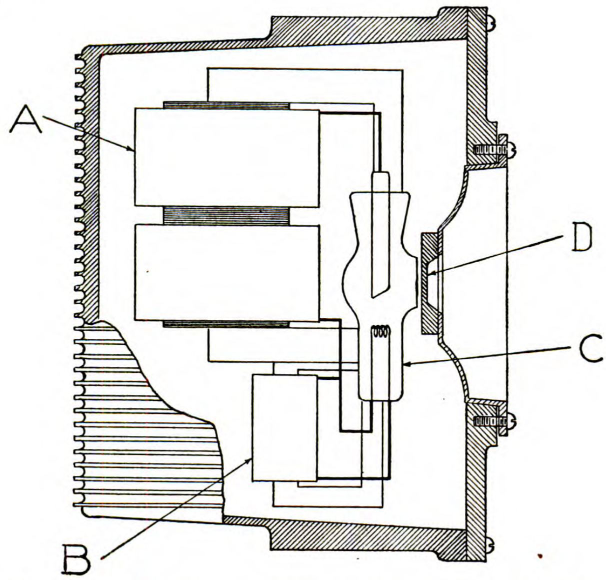

FIGURE 199.—Shock proof tube head. A, step-up transformer; B, filament transformer; C, X-ray tube; D, bakelite X-ray window. (General Electric X-ray Corporation design.)

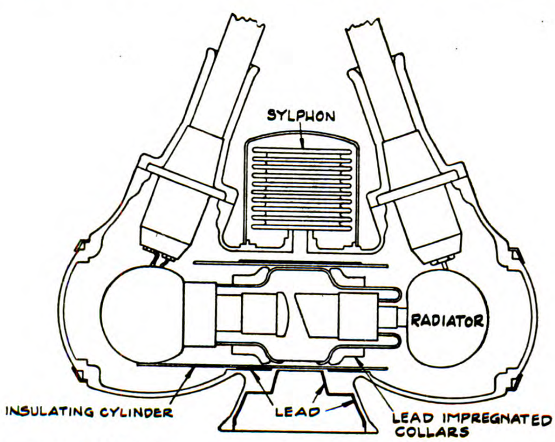

FIGURE 200.—Shock proof Coolidge tube unit—oil immersed. (General Electric X-ray Corporation.)

Film exposures.

Space prohibits a detailed description of the technique of film exposures. Many fine books have been written on this subject, at least one of which should be carefully studied. There are certain fundamental principles that must be followed if satisfactory films are to result:

1. The part should be as near the film as possible, otherwise, the shadow of the part will be much larger than the part itself.

2. The X-rays passing through the center of the part should usually strike the film at a right angle, otherwise the shadow will be distorted and difficult to interpret.

3. Standard positions as illustrated in technique should be strictly observed.

4. Standard target film distances should be used unless the X-ray equipment is too small for the necessary exposure. Chest films, for example, are usually made at a six or seven foot target film distance. A small bedside unit does not have the milliampere capacity to make such a chest film with a short exposure time. Hence, the distance is reduced to three feet. The amount of exposure necessary varies inversely as the square of the distance (inverse square law). The square of 6 feet is 36. The square of 3 feet is 9. By reducing the distance to 3 feet the amount of exposure necessary is as 36 is to 9. In other words, only one-fourth the number of milliampere seconds used at 6 feet is necessary at 3 feet. Variations in distance and voltage affect the film according to their squares. Variations in milliamperes and time have far less effect.

5. Motion must be eliminated by using compression bands, sand bags, head holders, etc., and by making sure that the patient holds his breath during the exposure. These important points are illustrated in technique books but usually are not emphasized. Motion frequently ruins a film completely for diagnositic purposes.

Scattering.

Scattering should be reduced by using cones, Bucky diaphragms and Lysholm grids. Figure 201 shows the principle of the Bucky diaphragm. When X-rays strike a patient's body many of them are broken up into stray X-rays (S) of longer wave lengths. The effect is similar to light passing through muddy water. These stray or scattered rays take different directions. Many of them strike the film and fog the image. Only the rays coming from the focal spot of the tube and passing straight through the body are wanted. Scattering increases with increased voltage, thickness of part, and size of area exposed. If the X-rays after leaving the body must pass through small slits between lead strips (L) and these strips are placed close together, very few rays outside of those coming from the direction of the target will get through. The scattered rays strike lead and are absorbed. The lead strips are kept moving during the exposure and thus do not show on the film.

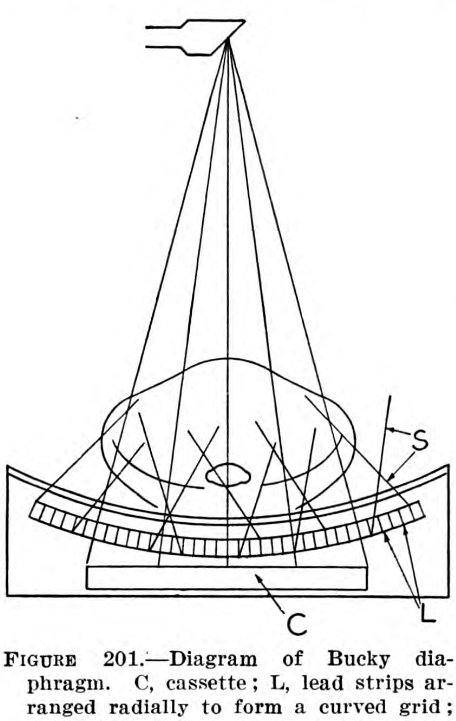

FIGURE 201.—Diagram of Bucky diaphragm. C, cassette; L, lead strips arranged radially to form a curved grid; S, scattered rays.

A Lysholm grid is made of very thin stationary lead strips placed closely together on a flat base. The shadows of the thin lead strips are not apparent on the film without close inspection. This grid is frequently placed behind fluoroscopic screens to overcome the blurring effect of scattered rays.

The simplest and cheapest way to overcome scattering is to use the metal cones that are supplied with most tube stands. The smallest cone is used that

will include the desired area of the body. Scattering is reduced because the X-rays are confined to a narrow field. This method is not efficient for large films but serves very well for the 8 by 10 size.

Potter-Bucky diaphragm.

In radiography of the thicker parts of the body, such as the spine, pelvis, kidney, gall-bladder, head, etc., increased penetration and time are necessary. The passage of the X-rays through these heavier parts materially increases secondary radiation. This secondary radiation, emanating in all directions from the point of origin, causes fogging, which renders the finer details unrecognizable in the film. Hence, in order to obtain radiographs of proper diagnostic quality, the elimination of as much of the unwanted radiation as possible must be accomplished. This is done by absorption of all except those rays that pass vertically or nearly vertically through the area examined. To accomplish this absorption the Potter-Bucky diaphragm is used.

The diaphragm consists of a metal frame holding a "grid" composed of thin, narrow strips of lead, separated by strips of wood. This grid is incorporated in a mechanism so arranged that it can be made to move at a steady, even pace across the plane between the film and the part examined. The speed with which the diaphragm moves can be controlled by the operator and should be regulated to correspond to the exposure time. The distance between the grid and part, as well as the distance between the grid and film, should be as slight as possible.

The absorption of secondary radiation necessitates a considerable increase in exposure time. This increase in time depends upon several factors in the construction of the grid, chief of which are the ratio between the widths of the lead and the wooden strips, and the depth of the grid. The increase in exposure time with the use of diaphragms ranges from 3 to 5 times that of exposure time without a diaphragm.

Bucky diaphragms are usually rated as "High-Speed," "Semi-Speed" or "Standard." "High-Speed" diaphragms are for use when very rapid work is desirable; they operate effectively with exposure times ranging from 1/20 of a second to 10 seconds. "Semi-Speed" diaphragms operate with an exposure time ranging from 1/10 of a second to 12 seconds. "Standard" diaphragms operate efficiently with exposure times ranging from ½ to 20 or more seconds.

Fluoroscopy.

The fact that certain crystals glow when excited by X-rays was what led to the discovery of the Rœntgen ray. When these crystals are finely divided and spread upon a suitable base, a fluoroscopic screen results. The original screen was composed of barium platino-cyanide crystals. After experimentation with thousands of crystals, in 1896 Thomas A. Edison discovered that calcium tungstate made ideal crystals for this purpose. Since then, cadmium tungstate and zinc sulfide have been found to serve best for fluoroscopic screens. The latter, however, are very sensitive to the actinic rays of sunlight and lose some of their fluorescing ability if exposed to direct light. Consequently, it is necessary to keep such screens covered with dark cloth when they are not actually in use.

Rœntgenoscopy is the study of bodies by use of X-rays and a fluoroscopic screen. When a patient or object is placed between the screen and the X-ray tube and the tube is activated, shadows, corresponding to the different densities of the part examined, can be outlined on the screen. As the difference in graduation of the shadows is very slight, absolute darkness is essential for careful examinations. For this same reason the eyes of the examining Rœntgenologist must be accommodated to the darkness. This accommodation requires a period

of several minutes in total darkness or may be accomplished by wearing dark or colored glasses. Glasses for this purpose have been manufactured and are in common use, having dark green or red lenses.

Fluoroscopy may be done in the operating room or at the bedside with hand or head fluoroscopes in conjunction with a portable or bedside X-ray unit. This fluoroscope consists of a small screen fitted into a light-proof cone. The latter is held before the eyes, either by means of a handle, or strapped to the head, according to the type used.

During fluoroscopy great care should be exercised that the patient or operator does not come in contact with the high-tension conductors. It should be borne in mind that great damage can be done by too long exposure to X-rays and that for this reason the examination should be as brief as practicable. The screen should contain a lead glass protective sheet between it and the operator, who should also wear heavy leaded rubber gloves and apron.

Radiography.

In fluoroscopy the shadows of the image examined are seen upon a screen. In radiography, the shadows are made a permanent record by means of photographic films.

Modern X-ray films consist of a special emulsion, containing a silver halide compound, coated in layers about $\frac{1}{1000}$ of an inch in thickness on both sides of a cellulose acetate support or base. This transparent base is about $\frac{1}{8000}$ of an inch in thickness, is slow burning, and presents somewhat less of a fire hazard than common newsprint paper. The base is usually slightly tinted with a blue pigment which aids in determining contrast in interpretation of the radiograph. Such a film is known as "*dupli-tized, safety film* with a *tinted base.*"

When a film is exposed to X-rays a change takes place in the silver halide salts. The salts that have been affected by exposure are converted into another silver compound through the action of a chemical solution called *developer.* The unaffected salts are then removed by another chemical solution called the *fixing solution.*

The emulsion of the X-ray film is affected by X-rays, radium, light, heat, moisture, chemical fumes, gases, static electrical discharges, scratching, abrasion, and contact with the fingers. Since any one of these things may cause defects to appear in the radiograph, it is evident that the greatest possible care must be exercised in their handling and storage.

PROCESSING PROCEDURE.—As X-ray films are extremely sensitive to white light, the processing to bring out and make permanent the radiographic image must be done in a "darkroom." Such a room may be illuminated by subdued green or ruby light, for it has been found that these lights do not affect the photographic emulsion of the film unless the latter is exposed to them for a considerable period. Naturally, as in all chemical procedures, processing should be carried out with scrupulous care as to cleanliness and ventilation.

After the film has been exposed it is quickly immersed in the developing solution. This solution contains the correct proportions of oxidizing agents which convert the affected silver salts into a form of metallic silver. As oxidization takes place only in a neutral or alkaline solution, the developer is strongly alkaline.

Development commences in the instant of submersion and continues until all the affected salts have been changed. The time of completion of this chemical reaction depends upon the temperature of the solution. It has been found that immersion of a film in a developing solution with a temperature of 65° F. for a period of 5 minutes will fully develop the recorded image. By decreasing

or increasing the developing time approximately 20 seconds for each degree of change in temperature, normal development may be accomplished in temperatures ranging between 60° F. and 70° F. Below the former or above the latter temperature, development should never be attempted unless in specially prepared solutions.

Powders compounded in the proper proportions are issued to all naval activities having X-ray facilities. The developing solution should be prepared as outlined in the instructions appearing on each container. Distilled water should be used if practicable.

There are several cautions that must be observed in mixing processing solutions. The vessels or pails should be made of glass or enamelware, for metals, such as galvanized iron, tin, copper, zinc, etc., will cause contamination, and result in fog in the radiograph.

After development, the film should be rinsed for about 30 seconds in clean, running water to remove as much of the developing solution as possible. If the film is transferred directly to the fixing bath from the developer, the alkali from the former solution retained on the film will neutralize some of the acid in the fixing solution. After a certain quantity of acid has been neutralized, the bath has lost its chemical balance; the hardening action is destroyed and stains are apt to appear on the radiograph.

The purpose of fixation is to remove all unexposed silver salts from the emulsion and to fix permanently the image that has been brought out by the developer. The fixing bath contains not only the fixing chemicals but also those chemicals that harden the gelatin of the emulsion, and it permits ordinary handling and filing of the film without damage.

The fixing solution ordinarily used in the naval service is prepared as follows:

ACID FIXING BATH

Sodium hyposulfite ("hypo")	2 lb. 8 oz.
Acetic acid (28% pure)	5.2 oz.
Sodium sulfite	1.6 oz.
Potassium alum	1.6 oz.
Water to make	1 gal.

(*To make 28% acetic acid from glacial acetic acid, take 3 parts of glacial acetic acid and add 8 parts of water.*)

To prepare the bath, dissolve the "hypo" in 48 ounces of water. The water used in dissolving the different ingredients should be at approximately 125° F. Dissolve the sodium sulfite in 32 ounces of water and when it is thoroughly dissolved, add the acid. Dissolve the alum in 32 ounces of water and mix with the sulfite-acid solution. Never add the alum before the acid, or a milky precipitate will result. Now mix the two solutions and add sufficient cold water to make 1 gallon, and stir. The solution must be free from debris and clear. If a milky precipitate results, known as sulfurization, an error has been made in the preparation and the solution should be discarded.

Proper fixation has occurred when the film is left submerged in the fixing solution twice as long as is required to remove all trace of the opalescent silver salts. This usually requires from 15 to 30 minutes, depending upon the strength and condition of the solution.

After fixation, the film should be washed in running water which is so circulating that all parts of the film and hanger receive frequent changes. If the hourly flow in the tank is 4 times the tank capacity, 30 minutes' wash will be

sufficient; if the hourly flow is 8 times the tank capacity, 15 minutes will usually be enough. If the flow of water is very slow, 45 or more minutes' washing will be required.

To process films properly, it is important that the temperature of the solutions and wash water be the same. The temperature of 65° F. has been selected as ideal.

The processing solutions after preparation should be allowed to stand for at least 24 hours to blend before they are put into routine use. They should be kept covered, when not in use, to prevent oxidation. When the level of the solutions has been lowered so that the film is not completely covered, fresh solution should be added. When preparing the solutions, it is a good plan to prepare an extra amount of each, putting the excess in tightly stoppered, amber-colored bottles, to use as the level of the solutions in the tanks is lowered.

The practice of adding chemicals to weakened or worn-out solutions should be discouraged. When the solutions become weak they should be thrown out and new ones prepared, for the use of worn-out solutions destroys the quality of the radiograph. New solutions should in any case be prepared at least every 4 to 6 weeks even if the number of films processed is not sufficient to cause exhaustion. Each gallon of developer should properly reduce approximately 5,200 square inches of dupli-tized film surface. Each gallon of fixing solution should fix and harden approximately 2,600 square inches of film surface, if films are properly rinsed before immersion.

After the film has been thoroughly washed, it should be dried. Most activities are equipped with "dryers", consisting of a cabinet with electric heating units and an electric fan. The air from the outside is drawn or forced in at one end of the cabinet, passes across the films and out through a duct at the other end. The efficiency of a dryer is about 24 films per hour.

Where no dryers are available, radiographs may be dried by hanging in the open air or before an electric fan. It must be remembered, however, that the wet film will pick up particles of dust, so it is important that they be dried in a dust-free room.

DARKROOM.—The darkroom should be large enough to care for the expectant work. It should be well ventilated, yet as nearly lightproof as possible. It must be kept scrupulously clean at all times and should be so arranged as to facilitate the handling of films, solutions, etc.

Such a room should contain the following items: Safe-lights for illumination; a master processing tank with at least two solution tanks and a wash compartment, connected to hot and cold running water regulated by a thermostatic mixing valve; a sink for mixing solutions; a film-loading bench into which is built a lightproof film-bin for storage of a small quantity of unexposed films; shelves and compartments for cassettes, film holders, chemicals, etc.; a film-drying cabinet; a lead-lined transfer cabinet; racks for storage of film hangers; towel rack; interval timer, and photographic thermometer.

STEREORADIOGRAPHS.—The principle of binocular vision is that, when objects are viewed with a normal pair of eyes, they appear in their true perspective; that is, they give a sense of depth. This results from the fact that each eye receives a slightly different view of the object and the two images are combined by the brain to give the plastic or stereoscopic impression.

A single radiograph does not possess perspective and is accordingly called "flat". It cannot indicate the position of the various parts of the object along the direction of vision. Hence, to overcome this deficiency in the ordinary radiograph, stereoscopic films are made. These are obtained by successively exposing two films, with the object, or part radiographed, and also the film,

in exactly the same position each time, but with a different position of the tube for each exposure. When these two films are viewed in a stereoscope, each eye sees one film only; but then, as in ordinary vision, the brain fuses the two images into one, showing the various parts standing out clearly in their true perspective.

The stereoscope consists of two viewing boxes with two mirrors exactly half way between them at a distance of 25 to 28 inches. The mirrors are so placed that the viewing box on the right can be seen only by the right mirror and the one on the left only by the left mirror.

As the average distance between the pupils of the eyes is 2.5 inches, it approximates 1/10 of the distance between each viewing box and its mirror. Consequently, when the tube is shifted 1/10 of the distance between the tube target and film, correct fusion of the images will be seen in the stereoscope. Stereoscopic radiographs should never be made at a distance of less than 25 inches.

In viewing stereoscopic films, the examiner should be in the same relative position as that of the target of the X-ray tube when the radiographs were made. Hence, the film taken with a right hand shift of the tube should be placed in the right-hand box and that taken with the left-hand shift in the left-hand box. Then, if viewed from this position, the object will appear to have solidity and relief.

INTENSIFYING SCREENS.—Certain chemicals become luminous when exposed to X-rays or other forms of radiation. This property is called fluorescence. Under the influence of X-rays, intensifying screens radiate the light thus produced to the X-ray film, held in close contact between them. The resultant density of the processed film is, therefore, due on the one hand to the quality and intensity of the X-rays, and on the other to the type of screen used.

The chemicals used in the manufacture of intensifying screens are crystals of calcium tungstate or of zinc sulfide. These finely divided crystals are spread over the surface of a thin sheet of cardboard and held together by means of a suitable binding material. The size of each crystal and the thickness of the coating determine the intensifying factor or speed of the screen. The active surface is glazed as a protective measure.

The intensifying action or speed of the screens lessens the time of radiographic exposure. The requirements in these screens should include the following points:

1. Screens of the same type should have uniform speeds.
2. They should produce no grainy effect in the radiograph due to large crystals.
3. They should be comparatively free from afterglow.
4. They should have a hard protective surface.
5. They should cause practically no loss in radiographic detail.

Screens produced by different manufacturers have varied intensifying factors. Classified according to speed, there are three general types of calcium tungstate screens: 1. Detail or definition (slow); 2. Mid-speed or par-speed (medium); and 3. Extra-speed or ultra-speed (fast). These types, obtained from three different manufacturers, were tested at the U. S. Naval Medical Supply Depot, Brooklyn, N. Y. All reached their maximum intensity at a potential of 65 kv. peak with comparatively no loss at higher potentials. The intensifying action of the "fast" type was only slightly greater than that of the "medium" type, but there was a greater loss in radiographic detail in the former. This would appear to indicate that there is no justification for the use of calcium tungstate screens of the "fast" type.

The zinc sulfide screen gives its maximum intensity at potentials below 70 kv. peak and is not recommended for use above that potential. It is of much higher speed than the calcium tungstate screen at low potentials and so is of great value for the radiographic unit of lower capacity. However, the zinc sulfide screen is extremely sensitive to secondary radiation emanating from heavy portions of the body which require greater kilovoltages for the penetration. Hence, if 70 kv. peak is exceeded, a Potter-Bucky disphragm should be used to absorb much of this secondary radiation. Because zinc sulfide screens are very susceptible to the actinic rays of the sun, they should never be exposed to direct sunlight.

The use of double intensifying screens decreases the necessary exposure time to about 1/20 of that used without screens. For example: Radiographs requiring a technique of 70 kv. peak, 10 ma., 25 inch film-target distance and 5 seconds' exposure time, without screens, will be duplicated, with the use of double intensifying screens, in approximately 1/4 of a second.

CARE OF SCREENS.—Intensifying screens, being very delicate and sensitive, should be handled with extreme care. Any particle of dirt or dust, any stain or scratch, will destroy their efficiency. Naturally, they gradually lose their fluorescing ability, but, with careful and conscientious use, screens should last for a period of approximately 18 months.

Rules for care of screens.—1. Active screen surfaces should not be touched by the fingers; 2. Chemicals, especially developer, will cause staining of the screen and impair its efficiency; 3. Cassettes should be brushed with a camel's hair brush at regular intervals to remove dust or small pieces of lint and paper due to insertion and removal of films; 4. Screens may be washed, when necessary, with a tuft of cotton, using warm water and a small amount of a pure soap. They should be rinsed immediately and dried before using. Since frequent washing impairs screen efficiency, it should be done only when absolutely necessary; and 5. Screens should be properly mounted in cassettes and good contact between screen and film maintained at all times to insure sharp detail in the radiograph.

X-RAY TREATMENT

The application of Rœntgen rays to the human body for treatment (therapeutic) purposes should not be attempted without the supervision of a medical graduate with special training and experience. Dangerous injuries to patients and technicians in recent years have usually occurred only when this rule has been broken.

Rœntgen therapy is divided into deep high voltage therapy and superficial low voltage therapy. The dosage is measured in Rœntgen units by special instruments. Modern deep therapy uses voltages of 200 kilovolts and higher. The longer wave lengths are absorbed by placing copper, tin, and aluminum filters between the tube and the patient. The resulting X-ray beam is composed of the shorter wave lengths which penetrate to the deeper tissues and have less effect on the skin. Superficial therapy uses voltages between 75 and 100 kilovolts with little if any filtration. Certain skin diseases respond well to the longer wave lengths produced by voltages around 10 kilovolts (Grenz rays). In superficial therapy most of the radiation is absorbed before it passes through the various layers of the skin.

PROTECTION

The safe operation of X-ray tubes demands that precautions be taken to avoid excessive radiation striking the patient or technician and to avoid contact with the high-tension electrical current.

Radiation precautions.

Serious changes in the skin occur when certain limits of radiation are exceeded. Patients have become permanently bald from too much X-ray exposure to the scalp. A safe working rule for radiography is to always use at least 25 inches target film distance and to always use an aluminum filter, one millimeter thick, in the tube holder. This filter absorbs long wave lengths that affect the skin but fail to penetrate through to the film. Under these conditions 1,200 milliampere seconds to any one part of the body should not be exceeded. When the limit is reached it takes about 30 days for the skin or scalp to recover so that it will take additional radiation without injury. This is true for voltages up to 85 kilovolts which is seldom exceeded in radiography. A bedside machine is frequently used at a 15 milliampere setting. When the exposures to the head (regardless of sides) total 1 minute and 20 seconds there have been 15 milliamperes for 80 seconds or 1,200 milliampere seconds. It is well to remember that 25 inches target film distance is about 15 inches target-scalp distance in the above example.

Dental radiography uses short target film distances and the danger of skin damage would be considerable were it not for the small cone that confines the X-rays to a small area. Always inquire about previous X-ray exposure. If several films have been taken of the same region during the previous 30 days, it is advisable to wait until 30 days have elapsed since the last exposure. A point frequently overlooked is the risk of making skull and sinus exposures directly after a full set of dental exposures and vice versa.

Radiation protection for the technician consists of keeping lead-lined walls or screens between the active tube and himself. Even with protected tubes such as shown in figures 187 and 201, this is the safest practice and the only protection against scattered or stray radiation. When assisting in the fluoroscopic room or operating bedside units, technicians should wear long aprons impregnated with lead. This protects most of the blood forming centers in the bones which are sensitive even to scattered radiation. Protective gloves should be worn if the duties require placing the hands nearer than 6 inches to the X-ray beam.

While the amount of radiation absorbed by a technician in one day is usually small, a small dose repeated daily over a period of months amounts to an alarming total. Technicians may determine whether or not they are absorbing dangerous amounts of radiation by the dental film method. Fasten two lead numbers, used for numbering films, to the exposure side of a dental film pack. This may be wrapped in one layer of black paper, for additional protection. Place the pack in a pocket with the exposure side out. After carrying for a full working day, develop and let someone not familiar with the numbers used inspect the film. If he can read the different numbers correctly on 3 of 5 films carried on 5 consecutive days, the technician is receiving too much radiation. There are several other methods of testing for radiation but they require equipment that is not always available.

The inside walls of radiographic and fluoroscopic rooms are usually lined with lead or coated with barium plaster to protect persons working habitually in adjacent rooms. The inside walls of rooms containing deep therapy equipment are usually lined with sheet lead of ⅛ inch thickness or more depending upon the kilovoltage used. If there are occupied rooms directly above and below, the ceilings and floors must also be protected.

Electrical precautions.

Only alert, mature individuals with good judgment should be allowed to operate equipment that involves risk of contact with high voltage. The habit

should be developed of looking and thinking before switches or push buttons are closed. Caution the patient not to move and do not allow spectators or attendants to approach any high-tension part. If the equipment has not been used for several days, or, in the case of bedside units, has been moved, it should be tested before the patient is placed in position. X-ray apparatus should not be accessible to anyone not responsible for its care and use. Accidents, breakdowns, and faulty performance frequently result from the curious tampering with controls and connections.

A good working rule is to never allow the tube terminals or any other high-tension part to come closer to the patient than twice the distance of the point spark gap. To allow for line surges, this distance should never be less than 1 foot. When the secondary coil of the transformer is grounded in the middle, the voltage at each end of the tube is one-half the total voltage. Nevertheless, it is safer to observe the working rule and not develop habits that might be carried to other apparatus. Remember that the autotransformer control with the resistance "cut out" allows dangerously high amperage to be drawn from a transformer when the high-tension is grounded.

Before approaching an X-ray tube or posturing a patient, see that the line switch and X-ray switch are in the "off" position. It will be recalled that timing devices and foot switches are merely convenient forms of X-ray switches. Any push button type of switch may stick and remain in the "on" position. For this reason it is safer to have the X-ray switch on a control stand connected in series with the timer and foot switch. The latter are then "dead" until the X-ray switch is thrown to the "on" position. Control stands with these devices connected in parallel are dangerous because a defective push button may close the circuit unbeknown to the operator. This is especially true of valve tube rectification whose operation is silent. To overcome this it is good practice to connect a warning light and buzzer in the primary circuit.

When high-tension jumps from its proper path it does so because it has found an easier path to follow. This simple fact is not so simple in practice. The easier path may be ionized air, defective or damp insulation, a patient's body, or a combination of these and several other factors. High-tension is always seeking a path to the ground. As a working principle, the path to ground through a patient's or operator's body should be made more difficult (contain more resistance) than some other paths that are not dangerous.

It is generally agreed that tube stands should carry a ground wire connected to a water pipe if possible and that they should not be in contact with radiographic tables. The latter should have a poor conductor in contact with the patient (such as a wooden table top) and should not have a connecting ground wire unless they collect static. A heavy charge of static electricity collects on some X-ray tables.

Fluoroscopic tables should be grounded because the patient is not between the tube and the table. Bedside units usually have a connection for a ground wire. This may be incorporated in the lamp socket connection of the unit for the low-tension wires will carry off a high-tension ground very efficiently. Otherwise, the ground wire should have a spring contact terminal that may be clamped to a radiator or water pipe. Never allow any part of the unit to touch the bed. See that the bed is not grounded by extension lights, radio ear phones, etc.

Floor coverings of X-ray rooms should be nonconducting material such as linoleum or rubber composition. To prevent the accumulation of ionized air, such rooms should be well ventilated.

X-ray protection.

An Advisory Committee on X-ray and Radium Protection was formed in the United States for the purpose of preparing unified safety recommendations. The complete recommendations of that committee are published by the U. S. Department of Commerce in the Bureau of Standards' Handbook, HB–20. The following excerpts from that publication are quoted:

"2. SPECIAL REQUIREMENTS FOR APPARATUS OF CLASS A.

(X-ray installations for diagnostic purposes at voltages up to 130 kv peak.)

"B. PROTECTION OF PATIENT

"2.03. The equivalent of 1 mm. of aluminum shall be permanently mounted between the tube target and patient in all fluoroscopic tube inclosures and 0.5 mm. of aluminum in all radiographic tube inclosures. Part or all of this may be contained in the glass of the tube walls.

"2.04. The diaphragm of the tube container shall have a permanent covering of asbestos board at least 0.5 mm. thick placed between the tube and filter, next to the filter.

"C. PROTECTION OF PHYSICIAN AND PERSONNEL

"Protection From Direct Radiation.

"2.05. The fluorescent screen shall be covered with plate lead-glass having an equivalent lead thickness of at least 1.5 mm.

"2.06. Protective gloves shall have an equivalent lead thickness of at least 0.5 mm., and shall insure protection to the whole hand—outer surface, palm, fingers, and wrist.

"2.07. Protective aprons worn by the physician or technician shall have an equivalent lead thickness of at least 0.5 mm.

"Protection From Scattered Radiation.

"2.13. To protect the operator and personnel, control apparatus for radiographic work should be in an adjacent room which provides protection equivalent to at least 0.5 mm. of lead. Control operators should be behind such protection during all radiographic exposures, and during all radioscopic work when practicable.

"2.14. When it is impracticable to place the control apparatus in an adjacent room, as in paragraph 2.13, it may be inclosed in a lead-lined booth within the radiographic room.

"2.15. Either control room or booth shall be provided with a suitably large lead-glass window of 2.0-mm. lead equivalent.

"2.16. The use of movable upright protective screens is dangerous and shall be discontinued.

"2.17. When thermionic rectifiers are used they shall be either placed in a separate room or surrounded by material of 0.1-mm. lead equivalent.

"10. HIGH-TENSION LEADS TO TUBES

"10.07. When using an X-ray tube having any exposed high-tension parts, the table shall be insulated from ground by suitable material capable of withstanding 3/2 the maximum working voltage to ground.

"10.08. Metal parts of X-ray apparatus, such as tube stands, transformer tanks, motors, controls, etc., shall be permanently grounded to a water pipe through at least a no. 6 AWG wire or the equivalent. This wire must be suitably protected against accidental breakage.

"IV. STORAGE OF X-RAY FILM

"15. General

"15.05. Smoking shall be prohibited in rooms where film is handled or stored. Conspicuous "No Smoking" signs shall be posted in prominent places.

"15.06. No films shall be stored within 2 feet of steam pipes, radiators, chimneys, or other sources of heat.

"V. OPERATING RULES

"16. Rules for technicians, nurses, etc.

"16.01. A copy of these rules shall be given to every X-ray worker, whether temporary or otherwise, upon entering service. A signed receipt stating that the rules are understood shall be given to the physician in charge of the department.

"16.02. A copy of these rules, together with a copy of first-aid instructions for electrical shock, shall be posted conspicuously in all principal X-ray rooms.

"16.03. Protective gloves and aprons, even though in compliance with these recommendations, do not afford adequate protection. Consequently, care shall be taken at all times not to expose the body unnecessarily to radiation.

"16.04. Lead rubber becomes hard and brittle with age, and all such protection should be tested at regular intervals for possible cracks and imperfections. This test should be made radiographically or radioscopically.

"16.05. Radioscopic work should be performed in the minimum time possible, using the lowest X-ray intensity and smallest aperture consistent with demands. It is important, however, that the fluoroscopist use sufficient X-ray intensity so that he can see without eyestrain.

"16.06. The omission of any protective devices for the sake of expediency of operation shall be strictly forbidden.

"16.07. Before touching any X-ray generator or high-tension part, particular care shall be taken to make sure that the main-line switch is open and the whole apparatus is disconnected from the power line.

"16.08. In the case of equipment having high-tension condensers, care shall be taken that both sides of the high tension are actually and securely grounded before touching any part thereof.

"16.09. If the transformer and controls are located in a remote room, a plaque reading "Do Not Touch" shall be hung over the main-line switch when it is necessary to touch high-tension parts in another room.

"16.10. Where several appliances for treatment or examination may be connected to a common high-tension system, care shall be taken that conductors to all idle equipment are disconnected.

"16.11. Where the machine operation depends upon two persons, a distinctly audible or visible signal shall be given by the operator before throwing on the high tension, and a return signal received from the person using the equipment.

"16.12. Any acoustical or optical signal system for protective purposes should be checked daily before commencing work.

"16.13. The main switch should be opened immediately upon completion of the X-ray work, or when the machine is not in actual use.

"16.14. The high-tension overhead system should be examined frequently for possible faulty insulators or loose parts.

"16.15. A daily check shall be made, to be certain that no idle flexible high-tension leads extend below the minimum prescribed height above the floor.

"16.16. All grounding connections shall be examined weekly.

"16.17. All high-tension barriers shall be examined frequently. When possible, this should be done when cleaning the apparatus.

"16.18. In case of fire in the X-ray or control rooms, or in any part of the building, all X-ray apparatus should be immediately disconnected from the mains by opening the main power line switch.

"16.19. All workers should be thoroughly familiar with the Schaefer prone pressure method of resuscitation in case of electric shock, and a set of such instructions should be posted conspicuously in each main room. Above the description of the method should be placed the instructions:

" 'This hospital may be provided with pulmotor or other resuscitation apparatus. Do not wait to send for it, but proceed immediately with the Schaefer prone pressure method.'

"17. RULES FOR PHYSICIANS IN CHARGE

"17.03. At least every 4 months each worker shall be supplied with a dental X-ray film half covered with lead foil, which shall be worn on the breast continuously, with the film side out, for 15 working days. If, upon development, appreciable darkening of the exposed part of the film is indicated, the cause therefor shall be investigated and eliminated.

"17.04. Circuit-breakers should be examined monthly to be certain that the overload adjustment is correct.

"18. PERSONNEL WORKING CONDITIONS

"18.03. Every assistant, technician, and operator should be given at least 4 weeks' vacation a year with at least 2 weeks of this consecutively and during the summer months.

"18.04. All persons occupied in radiological work should be examined for general radiation injuries yearly. Complete blood counts should be made frequently. The results of all tests and examinations should be permanently recorded. It is advisable that all persons be carefully examined before entering radiological work."

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